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ART. XVII.—*Observations on the Pluton Geysers of California;* by FOREST SHEPHERD,* Prof. Economic Geology, in Western Reserve College, Hudson, Ohio.

THERE is a tradition among the Indians of California, that not many years ago, the Chrysopylæ or Golden Gates at the entrance of the Bay of San Francisco were part of the solid land, and that the inland sea receiving the waters of the Sacramento and San Joaquin overflowed the beautiful valleys of San José, Napa and Sonoma, and had its outlet in the vicinity of Monterey.

Other more recent California explorers affirm that in the present bay of San Francisco they have discovered standing trees completely petrified, to which they have made fast their boats at low tide. The numerous dislocations observed in the tertiary strata, together with the great number of specimens of petrified wood and deposits of lignite found upon the shores of the bay, also signs of thermal action at the southeastern section of the bay, induced me to give so much credence to the above and other traditions, as to enter upon some careful examinations with reference to them. In the course of my investigations, I have explored some remarkable geysers in the Pluton valley; and these form the main subject of my present communication.

On my way to the Pluton valley, I first coasted around the Bay of San Francisco in an open boat, examining the rocks in its vicinity. At the entrance of Napa valley and about two

* From a letter addressed to Thomas Denny, Esq., New York city, and communicated by him to this Journal.

miles from the present tide, I discovered a belt of remarkably hard and heavy limestone, evidently fossiliferous and yet changed in some places by metamorphic action. In breaking into this bed of limestone, however, I was surprised to find imbedded in the solid rock, sharks teeth as perfect in their serrated edges as those of present living species swimming in the bay only two miles distant. I examined the range of hills eastward about one mile, which bounds and divides Napa valley from Suisun, and there I found the rocks to be a porphyry, with numerous springs flowing out at the base. I applied my thermometer and was surprised to find no two springs of the same temperature, they ranging from seventy-eight degrees Fahrenheit downward. I now travelled about thirty miles northward in Napa valley, following the above mentioned chain of hills to the thermal springs of Messrs. Ritchie and Tucker, where I found the temperature of different springs as follows:—

No. 1,	105 degrees, Fah.	No. 11,	132 degrees, Fah.
2,	120 "	12,	169 "
3,	144 "	13,	129 "
4,	133 "	14,	150 "
5,	147 "	15,	131 "
6,	144 "	16,	128 "
7,	129 "	17,	93 "
8,	124 "	18,	100 "
9,	120 "	19,	120 "
10,	131 "	20,	118 "

These springs are all embraced in a half mile square of level bottom land near the base of a small hill or mound of conglomerate rock about one hundred and fifty feet in height. The same kind of rock also extends underneath the springs. There is little or no opportunity for surface cold water to commingle with them, and it is a remarkable fact that they are continually changing their temperature, so that one that is now moderately warm will in the space of a few weeks or months become hot beyond endurance. This shifting of the internal heat greatly excited my curiosity, and on enquiring, I learned from Mr. Cyrus that the Indians had pointed out a place near the foot of Mount St. Helena where the hot waters formerly flowed, but had now ceased. I believed this to be a good opportunity to test the truth of their tradition, and repaired to the spot. Externally there was no uncommon appearance to designate the locality. Neither a surplus nor scarcity of vegetation, and no appearance of scoria, tufa or travertine, as might have been expected. I found one place, however, slightly warm on the surface, which on excavating to the depth of two feet became so hot that I could not bear my hand in the mud and clay. I inserted the bulb of my thermome-

ter, and the mercury at once rose to one hundred and twenty degrees. From observations already made by myself and in company with Professor James Nooney, I now felt that I could trace the line of thermal action, and my next object was to find the seat or focus of its greatest *intensity*. To accomplish this I was so fortunate as to have the aid of Messrs. P. Cyrus, J. Cyrus, and B. F. Briggs, three excellent young gentlemen and experienced hunters. We travelled northwesterly from the head of Napa valley, and after encamping one or two nights in the rain, and wandering through almost impenetrable thickets, reached the summit of a high peak on the morning of the fourth day. On the west we saw the vast Pacific. On the south, the Bay of San Francisco, Mount Diabalo,* Sonoma and Napa valleys. On the southwest, the valleys of Santa Rosa and Russian river. On the east, the lofty range of the Sierra Nevada: while on the north, almost immediately at our feet, there opened an immense chasm apparently formed by the rending of the mountains in a direction from west to east. The sun's rays had already penetrated into the narrow valley and so lighted up the deep defile, that from a distance of four or five miles, we distinctly saw clouds and dense columns of steam rapidly rising from the banks of the little river Pluton. It was now the eighth of February: the mountain peaks in the distance were covered with snow, while the valley at our feet wore the verdant garb of summer. It was with difficulty we could persuade ourselves that we were not looking down upon some manufacturing city, such as Pittsburg or Wheeling, until by a tortuous descent we arrived at the spot where at once the secrets of the inner world opened upon our astonished senses. In the space of half a mile square we discovered from one to two hundred openings through which the steam issued with violence, sending up columns of dense steam to the height of one hundred and fifty to two hundred feet, like our largest ocean steamers, and gradually diminishing to engines of one or two horse power. The roar of the larger tubes could be heard for a mile or more. The sharp hissing of the smaller ones is still ringing in my ears. Many of them would work spasmodically, precisely like high pressure engines. Throwing out occasional jets or volumes of hot scalding water some twenty or thirty feet, endangering the lives of those who rashly venture too near. In some places the steam and water come in contact so as to produce a constant "*jet d'eau*" or spouting fountain with a dense cloud above the spray, affording vivid prismatic hues in the sunshine.

Numerous cones are formed by the accumulation of various mineral salts and a deposit of sulphur crystals with earthy matter,

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* Mount Diabolo is reported to be an extinct volcanic cone.

which often harden into crusts of greater or less strength and thickness. Frequently the streams of boiling water would mount up to the top of the cones with violent ebullition. Some of the cones appear to be immense boiling cauldrons, and you hear the lashing and foaming gyrations beneath your feet as you approach them. It is then a moment of intense interest. Curiosity impels you forward—fear holds you back; and while you hesitate, the thin crust under your feet gives way, and you find yourself sinking into the fiery maelstrom below. The writer on one occasion heard the rushing of water under his feet. He struck down an axe which on the first blow went through into the deep whirlpool the whole length of the helve. He withdrew it and cut an opening, which revealed a stream of angry water, boiling intensely and of unknown breadth and depth. He continued to enlarge the opening until the stream was seen to be five or six feet in breadth, leading on indefinitely into the dark caverns beneath the mountain. This geyser is called *Agassiz's Maelstrom.*

Another place where a large volume of water boils up violently and settles in a circular basin and has also a steam tube by its side, is called *Silliman's Fountain.* Another, is named the *Panther Geyser*, from the circumstance that a huge wild panther had taken up his residence on the bank of the warm mound and seemed quite unwilling to leave his comfortable habitation. Another, where the waters gyrate with a loud noise "*in gurgite vasto*" is called *Pluto's Cauldron.* Another, the *Ocean Steamer, &c.*

At the base of the cones, in the bottom of the ravines, and in the bed and on the north bank of the river Pluton, springs almost innumerable break out, which are of various qualities and temperatures, from icy coldness up to the boiling point. You may here find sulphur water precisely similar to the celebrated *White Sulphur* of Green Brier County, Va., except its icy coldness. Also red, blue and even black sulphur water, both cold and hot. Also pure limpid hot water without any sulphur or chlorine salts, calcareous hot waters, magnesian, chalybeate, &c., in almost endless variety. Every natural facility is afforded for either vapor, shower or plunging baths. Where the heated sulphuretted hydrogen gas is evolved, water appears to be suddenly formed, beautiful crystals of sulphur deposited (not sublimed as by fire), and more or less sulphuric acid generated. In some places the acid was found so strong as to turn black kid gloves almost immediately to a deep red. Where the heated gas escapes in the river Pluton, such is the amount of sulphur deposited that the whole bed of the stream is made white for one or two miles below, similar to the White Sulphur Spring in Virginia. From numerous experiments made here and in the mountains of Virginia, I am confident that all sulphur springs possess a high temperature after descending below the cold surface water. Notwithstanding that

the rocks and earth in many places are so hot as to burn your feet through the soles of your boots, there is yet no appearance of a volcano in this extraordinary spot. Were the action to cease, it would be difficult after a few years to persuade men that it ever existed. There is no appearance of lava. You find yourself standing not in a solfatara nor one of the salses described by the illustrious Humboldt. The rocks around you are rapidly dissolving under the powerful metamorphic action going on. Porphyry and jasper are transformed into a kind of potters clay. Pseudo trappean and magnesian rocks are consumed much like wood in a slow fire, and go to form sulphate of magnesia and other products. Granite is rendered so soft that you may crush it between your fingers, and cut it as easily as bread unbaked. The feldspar appears to be converted partly into alum. In the meantime, the boulders and angular fragments brought down the ravines and river by the floods, are being cemented into a firm conglomerate so that it is difficult to dislodge even a small pebble, the pebble itself sometimes breaking before the cementation yields.

The thermal action on wood in this place is also highly interesting. In one mound I discovered the stump of a large tree silicified; in another a log changed to lignite or brown coal. Other fragments appeared midway between petrifaction and carbonization. In this connection, finding some drops of a very dense fluid and also highly refractive, I was led to believe that pure carbon might under such circumstances crystallize and form the diamond. Unfortunately for me however, I lost the precious drop in attempting to secure it.

A green tree cut down and obliquely inserted in one of the conical mounds, was so changed in thirty-six hours that its species would not have been recognized except from the portion projecting outside, around which beautiful crystals of sulphur had already formed.

From the thermal exhalations and the amount of sulphur deposited, it might be supposed that the progress of vegetation would be retarded. But such is not the fact. On the contrary it is greatly facilitated. The *Quercus sempervirens* or evergreen oak, flourishes in beauty within fifty feet of the boiling and angry geysers. Maples and alders from one to two feet in diameter, grow within twenty or thirty feet of the hottest steam pipes. This, however, may be accounted for by the cold surface water flowing down from the adjacent mountain. Here too the birds build their nests and "sing among the branches." Multitudes of grizzly bears make their beds on the warm grounds. Panthers, deer, hares, and squirrels, also take up their winter quarters in the very midst of the geyser mounds. Farther down the stream on the terraced banks of the limpid Pluton, vegetation (as one gentlemen has aptly expressed it) "*actually runs wild*," and the winter months exhibit all the fancied freshness of primeval Eden.

I have now traced the influence of this thermal action from two to three hundred miles on the Pacific coast in California, but only in this place have I been permitted to witness its astonishing intensity. The metamorphic action going on is at this moment effecting important changes in the structure and conformation of the rocky strata. It is not stationary, but apparently moving slowly eastward in the Pluton valley.

I would respectfully invite the attention of geologists to this cause of action, which hitherto has been too little studied and at present is not perfectly understood. The investigation will probably aid in accounting for the existence of many springs independent of ordinary Artesian flow, the formation of deep and varied soils, of beds of sulphur, rock salt, chalk, clay, hydrous iron ore, gypsum, &c., and perhaps extensive sections of breccia and conglomerate like those which traverse our continent.

California, March 17th, 1851.

ART. XVIII.—*Report of* Prof. ALEXANDER D. BACHE, *Superintendent of the United States Coast Survey, showing the progress of that work for the year ending October*, 1850. Ex. Doc., No. 12, 31st Cong., 2nd Session.

WE propose to devote a short notice, such as our space will allow, to the recent Report of Prof. A. D. Bache, Superintendent of the United States Coast Survey, showing the progress and state of that work, up to the latter part of 1850.

Our readers may be presumed to be somewhat acquainted with the nature of a work which has such an important bearing on the great interests of our country, and the advancement of science. We need, therefore, but briefly refer to the general plan and scope of the Survey.

The grand object—an accurate delineation of our coast and its adjacent waters—is pursued by a system; 1st, of primary triangulation, founded on the nice admeasurement of a base line, and embracing, wherever practicable, points of prominent interest—accompanied by astronomical and magnetic observations, for the determination of the latitude and longitude of such points, and the variation of the compass; 2nd, of more minute triangulation, and accurate topography of the shores; and 3d, of hydrographic observations, extending to all that may help the mariner to a knowledge of the dangers or facilities of our coast navigation, in the present, and all that may point out to the government judicious modes of indicating those dangers, or increasing those facilities, in the future.

The prosecution of this primary plan allows, and is used for, the incidental promotion, not only of the discovery of phenomena and laws which may afford new helps to the general science

of navigation, but also of a worthy contribution, from our country, to the great magazines of observations which the governments and *savans* of the civilized world are combining to store as the treasure house of future science.

The most distinguished foreign associations and journals have expressed their attentive admiration of the work, and the hopes which they indulge of its manifold results. We cannot forbear to instance the "Bulletin de la Société de Géographie," (Paris, Jan., 1851,) which, after an extended notice, adds; "In our mention of the eminent services rendered by the Coast Survey to science and to humanity, we have indicated but a small part of the results of this admirable enterprise. Directed in all its branches with zeal and activity, it cannot fail to add each year to the consideration with which it is regarded, not only in the United States, but in every country where science and its applications to the arts of life are justly appreciated." Of the present head of the work, it says: "The new superintendent was called with unanimity to this eminent post: signalized to the esteem of his fellow-citizens by useful publications, appreciated by the principal academies of Europe, he has acquired a universal renown by services daily rendered to science, and by ameliorations of every description introduced in the various branches of the Coast Survey."

Under the system established by the present superintendent, our coast has been divided into sections (nine for the Atlantic and two on the Pacific), in all of which the work is prosecuted simultaneously and separately. The different parts of the work will thus serve, in future, to verify each other, where the triangles meet. By this plan, moreover, the resulting benefits of the survey, instead of being postponed, or partially bestowed, are distributed throughout the country, during even the first stages of the work, in the different sections—a consideration, in its favor, of high practical moment, there being many cases, on various parts of our coast, in which even an approximation to accuracy of information is of immediate importance, to remedy the omissions or mistakes of existing charts.

The delineation of the Atlantic coast, as far south as that of North Carolina, has, in its essentials, advanced well nigh to completion; and a large number of extended and useful charts have been published. In our southern and western sections, the preliminary work is being rapidly pushed, together with, here and there, surveys in detail of important points, examined with a view to present necessities, or in compliance with special requests from the communities interested. Much valuable information, on those coasts, has indeed been already acquired and made public.

Within the past year, the harbor of Beaufort, N. C., has been surveyed, and a sketch published, as also of Oregon and Hatteras inlets, which sketches have been gratuitously distributed.

On the coasts of South Carolina and Georgia, the survey has been in progress since 1847. A base line has been measured on Edisto island, and the primary triangulation commenced. A preliminary base has been measured near Savannah, and the triangulation of that river commenced. The triangulation of N. Edisto inlet (harbor of refuge) is far advanced. The hydrography of Charleston harbor and bar is nearly completed, and hydrographic reconnaissances have been made off the sounds of St. Helena and St. Andrew.

In the Florida section, a reconnaissance of the Florida reef, keys, and adjacent main, has been completed from Cape Florida to the Tortugas. The topography and hydrography of Key West, and the adjacent islands and main, have been executed, a reconnaissance made of Cape Canaveral shoals, and one of Cedar Keys commenced. The work indicates a new channel for entering the harbor of Key West. This section was entered on in 1849.

On the coast of Alabama and Mississippi, the primary and secondary triangulations, entered on in 1846, are advancing. The hydrography and topography of Mobile bay and the delta near the city are completed.

In the section extending along the coasts of Louisiana and Texas, entered upon in 1848, the primary and secondary triangulations are in progress. The hydrography and topography of the approaches and vicinity of Galveston are nearly completed.

The parties sent to the coasts of Oregon and California have been hampered for want of means to carry on the work. The results, so far, have been—a general reconnaissance of the coast of California, from Monterey to the mouth of Columbia River, with charts and sailing directions—preliminary surveys of that river and of the bays of San Francisco and San Pablo—special observations and reports on Cape Conception, (which has been called the Hatteras of the western coast,) Cape Disappointment and some other prominent points.

From this general view, we may proceed to remark such striking features or new observations, especially with reference to their general scientific interest, as offer themselves in the report of Prof. Bache, under the respective heads of, 1st, the geodetic, and 2d, the hydrographic, portions of the work.

I. The correct measurement of a base line is the problem on whose practical solution must rest the accuracy of the Survey, in all its subsequent stages. Upon this head, the French scientific journal, before quoted, justly remarks that "many modes of procedure have been employed. The best, beyond all doubt, is that of Professor Bache, who by a skillfully arranged apparatus, has arrived at the most exact precision, and has succeeded in correcting several defective determinations of his predecessors."

The measurement is now pursued with an apparatus devised by Professor Bache, founded on the known system of compensating bars, but perfected by new precautions and nice contrivances of mechanical adjustment. Heretofore, no further approximation to accuracy of compensation had been attained, than resulted from joining together bars, of about the same size and surface, of different metals. The masses of the bars have been proportioned by Prof. Bache upon the principle that the absorption varies directly with the conducting power and inversely with the specific heat, of the material. Hence masses proportioned to the ratios of those constants, and having equal surfaces, from which conditions their linear dimensions may be deduced, would theoretically bear to each other the due compensating relation. Two sources of error however remain—the inexactness of the values assumed for those constants, and the different rapidity of absorption of the surfaces, during changes of temperature. These are obviated by proportioning the bars by actual experiment, subsequent to the calculated approximation, and by coating the materials respectively with varnishes suitable to each; so that the absorption of both will be equal in a given time and the compensating relation continue during changing temperatures. The bars while in use are constantly compared with the standard bar. They have been exposed beforehand to a higher temperature than they can be while in use, in order to give them a set, and are always protected by a covering, throughout the greater part of their length. These precautions, with arrangements for perfect contact, of which our limits forbid description, have ensured all the accuracy desirable. During the season embraced in this report, a base line of $6\frac{2}{3}$ miles was measured, in the whole of which the probable accidental error did not exceed one-tenth of an inch.

The Chesapeake triangulation will furnish the length of an arc of the meridian of over $2\frac{1}{2}$ degrees, measured, with but moderate deviation, on each side of the central meridian.

The local attraction at the astronomical stations having been found to modify essentially the determinations, those stations have been multiplied, and with the astronomical have been united magnetic and meteorological observations. The method of azimuth by observations at equal intervals before and after the culmination of a circumpolar star has given excellent results, requiring but brief computations.

By telegraphic connection with the coast stations, the observations of moon culminations and occultations at Cincinnati have been made available for differences of longitude from Europe. In general, it is to be remarked that the observations of scientific men, where they could be made available, have been procured for the Survey, and various distinguished professors have been employed to compute results from the materials accruing to the

work. In this wise, the appropriation for the Survey is made, while effecting its own end, to contribute to the maintenance and encouragement of a class devoted to science—and who may perhaps thus be assisted to repay their country in future fame, as well as in present labor.

In addition to the employment alluded to of telegraphic connections for determination of differences of longitude, researches have been prosecuted on the velocity of the galvanic current. A measurable interval having appeared in the recording of signals at different points, experiments were instituted, connecting the Washington station with Cambridge, Mass., St. Louis, and Charleston, S. C., under various circumstances. The results indicate a velocity of about 15,400 miles per second, by the iron wires, while it appears probable that, in passing *through the ground*, the wave has not a velocity exceeding two-thirds of the former. In the course of these experiments, interesting phenomena have been noticed, indicating apparent crossing and interference of the galvanic waves departing from the two poles of the telegraphic circuit.

Under an arrangement for ascertaining differences of longitude from Europe, by the transportation of chronometers, one series of results has been completed, and another is commencing. Mr. Bond, Director of the Cambridge Observatory, who had the immediate charge of the matter, states the very curious fact that the eastern passages give a greater difference of longitude than the western—and this too uniformly to be the result of accidental errors of the chronometers.

In the conduct of the Survey, it has been difficult to ascertain the best season for its various operations on different parts of the coast, the most pleasant weather not being always the most suitable, especially when the lines of sight are long. In the Florida section experience indicates the months from November to June (embracing parts of each, and including the intermediate months except March) as best for triangulation; and the same months, substituting March for June, as best for topography.

At the office of the Survey, the reproduction of engraved plates by the electrotype process has been pursued with complete success. The method consists in washing the plate with an alcoholic solution of iodine, and exposing to the action of a strong light, before placing it on the battery. In replacing a destroyed plate, the practicability has been proved of cutting up plates in the engraving, distributing the parts to several engravers, and reproducing the whole in one plate. The mode adopted was to secure the parts by screws to a copper plate and fill in with copper filings the intermediate spaces, made exceedingly small by close filing of the edges of contact. The metal formed was equally good throughout; and there remained only a few days' labor of an engraver to unite the parts.

II. The hydrographic surveys have yielded important discoveries of new and better channels, and of dangers heretofore unknown. Of the former class are Gedney's channel at the entrance of New York, Blake's in Delaware Bay, an entrance of twenty-one feet water on Mobile bar, and a new harbor on the dangerous coast of North Carolina. Of the latter, are the discoveries of Davis' and other shoals near Nantucket, in the most frequented path of commerce, several on the southern coast, and the new delineation of shoals off the coast of Maryland and off Cape Hatteras, differing almost entirely from the data previously furnished by the best authorities. Professor Bache remarks that such results, though more striking, are not more useful, than the accurate delineation of the harbors, bays, and sea-coast, which the ordinary operations are continually furnishing to navigators. He adds, that some of the differences observed between the recent surveys and those on which former charts were founded, are no doubt the results of actual changes; but there are no facts which prove that any important channel has been obliterated without being replaced by another, or has diminished in depth. The portions of our coast which really do change will be made known in the course of the survey, and the permanent marks furnished by the land work will permit re-examinations to be made, whenever required, at small expense and by ordinary means. The examinations relative to the entrance of Columbia river, heretofore so much dreaded by mariners, show that there have been great changes, but always a good channel, and its recent navigation has been without accident.

At various points, observations of tides and currents have been kept up minutely. Those of the tides at Cat Island are under discussion, as of a remarkable class, giving in general but one high and one low water tide during twenty-four lunar hours. These tides are supposed to depend upon the interference of the diurnal inequality (12-hour tide) wave with the semi-diurnal (6-hour tide) wave,—at least their variations may be traced and predicted from such a hypothesis.

The changes of a shore line by the action of storms and winds, and the encroachments of the sea upon the land, have been discussed by observers at Long Island and at Sandy Hook, respectively. The former of these infers, from tradition and examination, that deeper water is, in general, to be expected in the same places at present than formerly; but about the same depth at the same distance from the beach, as the sea probably carves out the same form of bed in all its course of encroachment. At Sandy Hook, where there has been a marked motion of its northern extremity to westward, the observer finds that, whenever there are natural obstructions to the wind, sand hills are formed and the beach preserved. He infers the feasibility of preserving and controlling the formation of the beach, by hedges

set with reference to the prevailing winds. At the same time, he regards the wind as having but small influence, as a first cause, in effecting these changes. The sand seems to be first thrown up by heavy seas and during storms, afterwards, when dry, to be carried about by the wind and deposited, until so near the level of high water as to be prevented by its dampness from rising with the winds.

In the western part of Mississippi sound, the water has changed from salt to fresh, owing to a crevasse through which the water of the Mississippi river enters Lake Ponchartrain, and thence reaches the Sound. The shell fish have been destroyed, and, if the crevasse continue, the character of that region may change materially.

The character, as well as the configuration of the bottom of the ocean is ascertained, and laid down on the charts of the Survey. Specimens of the bottom, obtained by soundings off the coast, are regularly collected and preserved. Their variety will often afford the mariner the means of relying on his lead for his position. The materials brought up in the deep sea soundings have, under the microscope, proved of the highest scientific interest. They have been already discussed by Professors Bailey and Agassiz.

Experiments have been made to ascertain the amount of uncertainty in ocean soundings, under different circumstances. The results obtained are of practical importance, as deciding the degree of accuracy necessary to be arrived at in observing the tides for the correction of soundings.

The observations of local attraction on board the iron steamer Jefferson have given the curious result of a difference not amounting to as much as four degrees, when heading towards opposite points of the compass. It is not known that any such case has ever before been observed.

In no point of view perhaps, can the results of the survey be made available for purposes of greater immediate importance, by the government to whom they are submitted, than in the establishment of light-houses, and the like facilities, for the guidance of our navigation. A wise selection is far more advantageous than an undue multiplication of such works. Accordingly, the attention of the parties employed in the various sections of the Coast Survey is constantly and minutely directed to the examination and selection of suitable points for light-houses, beacons, and buoys, and the determination of the best modes of construction for attaining the objects in view at the different localities. We trust that the attention of our government will not slumber over this subject, but that a judicious use of the knowledge thus acquired will cause to be devised and carried out, a system which shall lend new wings to our commerce, alleviate the hardships and lessen the dangers of the mariner, and lighten the hearts of those at home, whose fancy tracks in dreams his dangerous path.

Art. XIX.—*On Coral Reefs and Islands;* by James D. Dana.—Part Third.

From the Report on Geology of the Exploring Expedition under Capt. Wilkes, U.S.N.

Structure, Growth, and Habits of Coral Zoophytes.

1. *Structure and Growth of Zoophytes.*

A singular degree of obscurity has been thrown around the growth of coral zoophytes and coral formations, through the various speculations which have been offered in place of facts; and to the present day, the subject is seldom mentioned without the qualifying adjective *mysterious* expressed or understood. Some writers, scouting the idea that reefs of rocks can be due in any way to "animalcules," talk of electrical forces, the first and last appeal of ignorance. Others call in the fishes of the seas, suggesting that they are the masons, and work with their teeth in the accumulation of the calcareous material. Very many of those who discourse quite learnedly on zoophytes and reefs, imagine that the polyps are mechanical workers, heaping up these piles of rock by their united labors; and science still retains such terms as polypary, polypidom, as if each coral were the constructed hive or house of a swarm of polyps, like the honeycomb of the bee, or the hillock of a colony of ants.

It is vain to hope to understand fully the works of Him who is himself infinite and incomprehensible. The scrutinizing eye of science penetrates with far-reaching sight the system of things about us, and in the dim limits of vision reads everywhere the word mystery. All life, animal and vegetable, and all that is inanimate, declare it; surely there is no special reason, except such as may arise from want of study and consideration, for attributing it pre-eminently to the humblest grades of existence.

It is not more surprising nor a matter of more difficult comprehension that the polyp should form coral, than that the quadruped should form its bones, or the mollusc its shell. The processes are similar, and so the result: in each case it is a simple animal secretion, a formation of stony matter from the aliment which the animal receives, produced by certain parts of the animal fitted for this secreting process. This power of secretion is the first and most common of those that belong to living tissues; and though differing in different organs according to their end or function, it is all one process, both in nature or cause, whether in the animalcule or in man. Coral is never, therefore, an agglutination of grains made by the handywork of the many-armed polyps: for it is no more an act of labor than bone-making in ourselves. And again, it is not a collection of cells into

which the coral animals may withdraw for concealment, any more than the skeleton of a dog is its house or cell: for every part of the coral of a polyp in most reef-making species is enclosed *within* the polyp, where it was formed by the secreting process.*

It is important that this point should be thoroughly understood, and fully appreciated. That error may no longer be perpetuated, the words polypary and the like, have been rejected by the author in his volume on Zoophytes, and the more familiar term *corallum* has been used instead.† With this introductory explanation, we proceed.

a. Structure of Coral Animals or Polyps.—A good idea of a coral polyp may be had from comparison with the garden aster: for the likeness in external form and delicacy of coloring is singularly close. The aster consists of a tinted disk bordered with one or more series of petals; and in exact analogy, the polyp-flower, in its most common form, has a disk often richly colored, fringed around with petal-like organs called tentacles. Below the disk, in contrast with the slender pedicel of the plant, there is a stout cylindrical pedicel or body, often as broad as the disk itself, and usually not much longer, which contains the *stomach* and internal cavity of the polyp: and the *mouth*, which opens into the stomach, is placed at the centre of the disk. Here, then, the flower-animal and the garden-flower diverge in character, the difference being required by the different modes of nutrition in the two kingdoms of nature.

There are many species of polyps, which have all the external and internal characters of coral polyps, yet secrete no lime or coral. Our descriptions of structure may be best drawn from them, and afterwards the single peculiarity of the coral-making polyp—its secretion of coral—will come under consideration. The species here referred to are called *Actiniæ* in science, in allusion to the radiated or aster-like flower which forms the summit of the animal.‡ There is the same allusion in the common appellation *Sea-anemone*. The richest anemones, daisies and tulips of our gardens would not rival them in beauty, neither will

* It is not, perhaps, within the range of science to criticise the poet; yet we may say in this place, in view of the frequent use of the lines even by scientific men, that more error in the same compass could scarcely be found than in the part of Montgomery's Pelican Island, relating to coral formations. The poetry is beautiful, the facts nearly all errors—if literature allows of such an incongruity. For ourselves, we think the poet transcends his appropriate limits when false to nature.

† See page 15, of the Report on Zoophytes. The term Corallium has been set aside by authors because of its being used for a genus of corals. *Corallum* is an old form of the same word, as particularly explained on the page just referred to, and is not liable to this objection. The true nature of calcareous corals was first pointed out by Milne Edwards and Ehrenberg.

‡ From ακτις, *a ray of the sun.*

they exceed them in the size of their flowers; for a breadth of two and three inches is common. The polyps here alluded to, along with the coral polyps allied, constitute the order or division of zoophytes called ACTINOIDEA.*

The Actiniæ are entirely fleshy, and usually live attached by their lower extremity to the submerged rocks of the shores. The mouth, at the centre of the flower-like disk forming the summit of the animal, is a simple opening without teeth or appendages of any kind. The tentacles—the petals of the flower—are tubular organs, and communicate internally with the interior cavity of the animal. The animal contracts, when disturbed, and conceals the flower by rolling inward over it the margin bearing the tentacles; and in this state it seems like a lifeless lump of animal matter. Left quiet for a while, it again expands and appears as before. This expansion is produced by receiving water into the interior from without, mostly through the mouth, and thus filling the tentacles and swelling out its fleshy body. They are generally found expanded with the mouth wide open to receive their prey. As they are fixed to the rocks, they must wait for their food to come to them. When a crab, shell-fish, or anything alive, within the capabilities of their bodies, comes within reach, they usually secure it by closing upon the victim the tentacles, (which commonly have a stinging power,) and pushing it into the mouth. In many species the tentacles are too short to aid in capturing food except it be by stinging. These organs subserve also the purpose of aerating the blood, a function in which all parts of the body are more or less concerned.

The interior of the actinia contains a cylindrical stomach suspended from the disk, which opens at bottom into the general cavity of the body. This general cavity, below the stomach and around it, is divided into compartments by radiating fleshy lamellæ, the larger of which in their upper part connect the stomach with the sides of the animal. The most important function of these lamellæ is that of reproduction, some being spermatic, and the others bearing clusters of ova. These ova leave the body by passing out through the stomach and mouth; but in many instances this does not take place till the young animal has proceeded from them. The refuse from the food after digestion in the stomach is also ejected by the mouth, as this is the only opening to the alimentary cavity. Other excrementitious matters, separated on the final elaboration of the chyle and its assimilation, may escape through the sides of the animal, the openings at the extremities of the tentacles, or in general by whatever pores or passages water may be ejected in the contraction of the animal.

* This term alludes to their general resemblance to Actiniæ.

One of the most singular peculiarities of polyps is their ready restoration of a lost part. Even a fragment will go on to complete the entire animal again: as with the fabled hydra of old, the knife is used but to multiply, for every section becomes a new animal.

In all the points mentioned in the description here given, the polyp of ordinary coral and the actinia are identical.

b. Process of Budding.—There is one mode of reproduction which, although having no necessary connection with coral secretions, belongs almost exclusively to coral polyps. This is *reproduction by buds;* and the process is so similar to the production of buds in vegetation, that a remembrance of the latter will aid much in conceiving of it. The bud generally commences as a slight prominence on the side of the parent: the prominence enlarges, and soon a circle of tentacles grows out, with a mouth at the centre; enlargement goes on till the young finally equals the parent in size. Thus by budding, a compound group is commenced; and it is evident that if the parent and the new polyp go on budding again, and so on, the compound group may continue to enlarge. This is the fact in nature. The polyps, one and all, continue propagating by buds, until in some instances thousands, or hundreds of thousands, have proceeded from a single one, and the colony has spread to a large size. Such is the Madrepora and Astræa. There are modifications of this process, analogous to those in vegetation, but we need not dwell upon them in this place.

It is obvious that the connection of the polyps in such a compound group must be of the most intimate kind. The several polyps have separate mouths and tentacles, and separate stomachs; but beyond this there is no individual property. They coalesce, or are one, by intervening tissues, and there is a free circulation of fluids through the many pores or lacunes. The zoophyte is like a living sheet of animal matter, fed and nourished by numerous mouths and as many stomachs. In some species the coalescence is confined to the lower half of the polyps, or to a still less part; and in this case the animals project above the general living surface. Polyps thus clustered, spreading at summit a star of tentacles, constitute the flowering zoophytes of coral reefs.

Those coral animals which do not bud are to all external appearance true actiniæ. The existence of coral in the living coral zoophyte is nowhere apparent, and would not be suspected if not previously known; for, as before stated, it is wholly internal, and the visible exterior is the fleshy skin of the polyp.

c. Secretion of Coral.—We have already remarked on the general nature of coral secretions. These secretions, it should be farther observed, increase within simultaneously with growth,

and every new animal adds to those previously formed. They go on throughout the sides and base of each polyp, excepting generally the exterior skin, as above stated; and the whole forms a calcareous framework penetrated by the animal tissues, some of these tissues corresponding to and occupying the cellules of the corallum, and others penetrating the solid parts in minute ramifications. Coral is also secreted between the radiating fleshy lamellæ of the internal cavity of the polyp, producing the radiated calcareous lamellæ which constitute the star of a cell. In the corallum of a Madrepora or an Astræa each surface cell or star belonged to a separate polyp, and the star was formed as here explained.

It would lead to too long a digression from the main topic before us to explain the principles upon which the forms of zoophytes depend. They are dwelt upon at length in another volume. In this place we may briefly allude to the principal varieties of form proceeding from the budding process, and to a single point in their mode of growth, upon which much of their importance in reef-making depends.

d. Forms of Actinoid Zoophytes.—Zoophytes imitate nearly every variety of vegetation. Trees of coral are well known; and although not emulating in size the oaks of our forests,—for they do not exceed six or eight feet in height,—they are gracefully branched, and the whole surface blooms with coral polyps in place of leaves and flowers. Shrubbery, tufts of rushes, beds of pinks, and feathery mosses, are most exactly imitated. Many species spread out in broad leaves or folia, and resemble some large-leaved plant just unfolding: when alive, the surface of each leaf is covered with polyp flowers. The cactus, the lichen clinging to the rock, and the fungus in all its varieties, have their numerous representatives. Besides these forms imitating vegetation, there are gracefully modelled vases, some of which are three or four feet in diameter, made up of a network of branches and branchlets and sprigs of flowers. There are also solid coral hemispheres like domes among the vases and shrubbery, occasionally ten, or even twenty feet in diameter, whose symmetrical surface is gorgeously decked with polyp-stars of purple and emerald green.*

All the many shapes proceed in each instance from a single germ, which grows and buds under a few simple laws of development, and thus gives origin either to the branch, the broad leaf, the column, or the hemisphere.

e. Life and Death in Concurrent Progress.—But the more massy forms would not exist, and others would be of diminutive

* See Report on Zoophytes, pp. 29 and 59–61.

size, were it not for a peculiar mode of growth which characterizes most coral zoophytes.

Life and death are here in concurrent or parallel progress, a condition favored by the existence of coral secretions. In some instances, a simple polyp, while growing at top and constantly lengthening itself upward, is dying at its lower extremity, leaving the base of the coral bare, and destitute of any living tissues. The polyp thus continues rising in height, and death progresses below at the same rate, till at last the live polyp may be at the extremity of a coral stem many times its own length. This process is illustrated by figures on pages 62 and 78 of the Report on Zoophytes.

In species which bud and form large groups, the same operation takes place. In some instances the summit polyp or polyps bud and grow, while at a certain distance below the summit, the work of death is going on and polyps are gradually disappearing. There is thus a certain interval of life, the length of which interval is different for different species. There are zoophytes which grow to a height of several feet, and still only the upper one or two inches are living. The recent polyps at the top of the column are active with life and vigorous in reproduction, while the more aged below, having reached the fixed limits of their existence, are disappearing. The enduring coral remains, and constitutes the basement or stage of action for future generations of polyps.

But this death is not in progress alone at the base of the column or branch. Generally the *whole interior* of a corallum is dead, a result of the same process with that just explained. Thus, a Madrepora, although the branch may be an inch in diameter, is alive only to a depth of a line or two, the growing polyps of the surface having progressively died at their lower or inner extremity as they increased outward.

The large domes of Astræas, which have been stated to attain sometimes a diameter of ten or twenty feet, and are alive over the whole surface, owing to a symmetrical and unlimited mode of budding, are nothing but lifeless coral throughout the interior. Could the living portion be separated, it would form a hemispherical shell of polyps, in most species about half an inch thick. In some Porites of the same size, the whole mass is lifeless, excepting the exterior for a sixth of an inch in depth.

With such a mode of increase, there is no necessary limit to the growth of zoophytes. The rising column may grow upward, until it nears the surface of the sea, when death ensues simply from exposure, and not from any failure in its powers of life. The huge domes may enlarge till the same exposure just mentioned causes the death of the summit, and leaves only the sides to grow, which may increase indefinitely. Moreover, it is

evident that if the land supporting the growing coral were very gradually sinking, the upward increase of the coral might still be without limit.

There is hence sufficient means provided for the production of coral material for islands, however numerous. These humble ministers of creative power might, without other attributes than those they now possess, have laid the foundations of continents, and covered them with mountain ranges. This remark requires no limitation if we allow the requisite time, and connect with the power of growth such other agencies, soon to be explained, as have been at work in the Pacific since the reefs were there in progress.

The death of the polyps about the base of a coral tree would expose it seemingly to immediate wear from the waters around it, and especially as the texture is usually porous. But nature is not without an expedient to prevent a catastrophe that would be destructive to a large part of growing zoophytes, and would prevent the indefinite increase just explained. The dead surface becomes the resting-place of numberless small incrusting species of corals, besides Nullipores, Serpulas, and some molluscs. In many instances the lichen-like Nullipore grows at the same rate with the rate of death in the zoophyte, and keeps itself up to the very limit of the living part. The dead trunk of the forest becomes covered with lichens and fungi, or in tropical climes, with other foliage and various foreign flowers: so among the coral productions of the sea, there are forms of life which replace the dying polyp. The process of wear is thus entirely prevented.

The older polyps, before death, often increase their coral secretions within, filling the pores occupied by the tissues, and rendering the corallum more solid; and this is another means by which the trees of coral growth, though of slender form, are increased in strength and endurance.

The facility with which polyps repair a wound, aids in carrying forward the results above described. The breaking of a branch is no serious injury to a zoophyte. There is often some degree of sensibility apparent throughout a clump, even when of considerable size, and the shock, therefore, may occasion the polyps to close. But in an hour, or perhaps much less time, their tentacles will have again expanded; and such as were torn by the fracture will be in the process of complete restoration to their former size and powers. The fragment broken off, dropping in a favorable place, would become the germ of another coral plant, its base cementing by means of coral-secretions to the rock on which it might rest; or if still in contact with any part of the parent tree, it would be reunited and continue to grow as before. The coral zoophyte may be levelled by transported masses swept over by the waves; yet like the trodden

sod, it sprouts again, and continues to grow and flourish as before. The sod, however, has roots which are still unhurt; while the zoophyte, which may be dead at base, has a root—a source or centre of life—in every polyp that blossoms over its surface. Each animal might live and grow if separated from the rest, and would ultimately produce a mature zoophyte.

We close this review of the characters of coral animals, which is a mere abstract of the fuller descriptions in the General Report on Zoophytes, by alluding briefly to a second division of Zoophytes, not yet touched upon, and also to the Hydroidea and Bryozoa, which are likewise coral-making animals.

The Alcyonoidea.—The polyps of the Alcyonium* group of zoophytes differ from those which have been occupying us, in having but eight tentacles, and these are fringed with minute papillæ. The organ-pipe coral (Tubipora) is of this kind. When expanded in the sea, a clump resembles a bed of pinks, or looks like a lilac-cluster that had been dropped in the water; and this resemblance extends to the color and size of the flowers as well as their form.

Some of these zoophytes secrete lime and form a tube; and of this kind is the Tubipora. Others secrete only scattered granules of lime through the tissues: and still others are fleshy throughout. Many of them, besides forming granular calcareous secretions within the body of the polyp, give origin to a horny secretion at base, analogous to the epidermic secretions (hair, nails) of other animals; and this secretion receiving constant additions from the polyps as they are successively budded out, forms the axis of the growing branch. Of this character is the horny axis of the Gorgonia or sea-fan, which was long taken for a vegetable production. The crust which covers the axis consists of united polyps, which expand over its surface; and when expanded, each branch becomes a spike of flowers.

The Hydroidea.—The Hydroidea include the groups Hydra, Sertularia, Tubularia and the allied. Some species form thready tufts and plumes of extreme delicacy and others (the Hydræ) are simple polyps. The fine branchlets of the feathery species consist when dead of one or two series of microscopic cells arranged like tiny cups, tubes or goblets along the stem; and when alive, each cell is the site of a minute flower-animal. A coronet of tentacles surrounds the mouth, as in the Actiniæ, though somewhat different in character. The internal cavity is a simple tube without radiating lamellæ or special organs of reproduction, and the gemmules grow out singly or in bunches from the sides of the

* This name is derived from Alcyone, the fabled daughter of Neptune, and although from a Greek word having the aspirate breathing to the first letter, it was written by the Latins as here, (and by Linnæus and others,) without the H.

animal. The Hydra, an animal a line or two in length, consists of a tubular body, with a mouth at one extremity surrounded by a circle of tentacles: and the structure of the animal is so simple that it may be turned inside out, and still live and eat; it may be cut into forty or more parts, and from the dissected body, will grow as many distinct Hydræ. The Hydroidea are all minute and act no important part in reef-making.

The Hydroidea were long considered mature animals. But recent investigations have shown that part at least develop Medusæ, which are properly the adult individuals since these alone produce true ova. This division has therefore been recently removed from the zoophytes and placed with the Acalephs or Jelly-fishes.

The Bryozoa.—The Bryozoa are other coral-making species; but they are related to certain molluscs called Ascidiæ rather than to zoophytes. In habit and size they much resemble the Hydroidea. From a minute cabin-like cell, they extend a circlet of slender arms or tentacles, and expand into a delicate goblet-shape flower, seldom over a line in diameter. These polyps differ both from the Actinoidea and Hydroidea, in having two extremities to the alimentary canal—an anus, as well as a mouth; the intestine curves around and terminates in the disk. They are widely removed from true zoophytes, both by this character, and also by having the tentacles furnished with vibratile cilia—that is, minute appendages resembling short hairs, which are kept in nearly constant vibration.

Some species of Bryozoa form thin crusts over rocks or seaweeds, consisting of united cells, scarcely distinguishable unless magnified. The coralla of other species are branching or thin foliaceous; and these also consist of series of minute cells.

2. *Texture and Composition of Corals.*

The *texture* of calcareous corals is in general quite porous or cellular. Small stars or rounded depressions are scattered over the surface, and sometimes these stars form the centres of small prominences, called calicles (little cups). Besides these polyp-cells, which mark the position each of a separate polyp, there are pores or cellules penetrating the texture of the coral mass; yet in some zoophytes, the coral secretions continue increasing in the animal till the pores are almost or quite obliterated, and the texture is nearly compact, the polyp cells alone remaining. In many species, wherever there are concavities of much depth in the surface of a zoophyte, the coral of these concavities is looser or more spongy than elsewhere, for the reason, apparently, that the polyps in such parts have a poorer chance for securing food and fresh portions of water.

In the Gorgoniæ, and other species forming a distinct axis to the branches, this axis is solid, without a trace of a cell, and

usually with faint evidences of a concentric structure. It is thus that the red coral of commerce, used in jewelry, differs from the Madrepore or common white coral: it is the *axis* of a species of Corallium; and the polyps constituted a layer about it, in the same manner as the polyps of Gorgoniæ cover the horny axis of these species.

In *hardness*, the common calcareous corals are a little above ordinary limestone or marble, the degree being represented in the mineralogical scale of Mohs by 3·5 to 4, while, in limestone, it is about 3. The ringing sound given when coral is struck with a hammer, indicates this superior hardness. It is a common error of old date to suppose that coral when first removed from the water is soft, and afterwards hardens on exposure. But, in fact, there is scarcely an appreciable difference; the live coral has a slimy feel in the fingers; but if washed clear of the animal matter, it is found to be quite firm. The waters with which it is penetrated may contain a trace of lime in solution, which evaporates on drying, and adds slightly to the strength of the coral, but the change is hardly appreciable. A branched Madrepore rings on being struck when first collected; and a blow in any part puts in hazard every branch throughout it, on account of its elasticity and brittleness. Its *specific gravity* varies from 2·5 to 2·8: 2·523 was the average from fifteen specimens examined by Prof. B. Silliman, Jr.*

In *composition*, the common reef-corals, of which the branching Madrepora, and the massive Astræas are good examples, consist almost wholly of carbonate of lime, the same ingredient which constitutes ordinary limestone. In 100 parts, 90 to 96 parts are of this constituent; of the remainder, there are 3 to 8 parts of organic matter, with some earthy ingredients amounting in certain species to 2 parts, though often less than 1. These earthy ingredients are silica, magnesia, alumina, oxyd of iron, phosphate of magnesia, and fluorids of magnesium and calcium. The following is the result of one of Mr. Silliman's analyses from those made by him for the Report on Zoophytes.† The specimen was a Porites from the Sandwich Islands. It afforded—

Carbonate of lime, . . .	95·84
Phosphates, fluorids, &c., . .	2·05
Organic matter, ...	2·11

The various earthy ingredients are included in the second line of the analysis, in this species amounting to 2·05 per cent. One

* Report on Zoophytes, page 713. On page 711, it is suggested by the author that the high degree of hardness, which characterizes corals and also the shells of many molluscs, may arise from the structure of the calcareous secretions being like that of arragonite, instead of common calc-spar. The hardness is near that of arragonite, though sometimes a little exceeding it.

† Op. cit., p. 712, and this Journal [2], i, 189.

hundred parts of the same, subjected to exact analysis, gave the following result:—

Silica,	22·00
Lime,	13·03
Magnesia,	7·66
Fluorid of calcium,	7·83
Fluorid of magnesium,	12·48
Phosphate of magnesia,	2·70
Alumina (and iron),	16·00
Oxyd of iron,	18·30

In other analyses similar results were obtained, with sometimes a larger proportion of fluorids.

The horny corals, (axes of Gorgoniæ and Antipathi,) were found by Hatchett to have nearly the constitution of ordinary horn.*

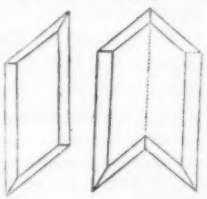
The sea-water and the ordinary food of the polyps are evidently the source from which the ingredients of coral are obtained. As coral is an animal secretion, there is no good reason for the surprise with which this subject is sometimes approached. The same powers of elaboration which exist in other animals belong to polyps; for this function, as we have remarked, is the lowest attribute of vitality.

Neither is it at all necessary to inquire whether the lime in sea-water exists as carbonate or sulphate, or whether chlorid of calcium takes the place of these. The powers of life may make from the elements present whatever results the functions of the animal require.†

Various waters were collected in the vicinity of the coral islands, and at different distances from them, for the purpose of analysis in order to compare the constitution of the sea in different parts; but they were lost with the Peacock on the bar of the Columbia river. The proportion of lime salts which occurs in the water of the ocean is about $\frac{1}{30}$ to $\frac{1}{35}$ of all the ingredients in solution. Prof. Forchhammer has ascertained that around the West Indian seas, where corals abound, lime is not as abundant as elsewhere in the ocean, the proportion, according to five analy-

* Report on Zoophytes, p. 56.

† If a drop of sea-water be slowly evaporated under a microscope of high power, crystals of selenite (sulphate of lime) are produced, having the annexed forms, the most common presented by native crystals of this mineral, as stated in works on mineralogy. On adding more water, they are again dissolved; and this may be repeated indefinitely. These results would seem to indicate that the lime was mostly in the state of a sulphate.



Mr. Darwin states the remarkable fact, described by Mr. Webster, (Voyage of the Chanticleer, ii, 319,) that a deposit of salt and gypsum two feet thick occurs on the shores of Ascension, which was formed by the dash of the waves. Beautiful crystals of selenite were obtained by the writer in logs of half decomposed wood in the shore cliffs near Callao, which were of similar origin.

ses, being 247 to 10,000; while in the Kattegat, where the rivers of the Baltic carry it in considerable quantities, the proportion, from four analyses, is 371 to 10,000.* Schweitzer obtained the following result for water taken from the British Channel.†

	Grains.
Water,	964·74
Chlorid of sodium,	27·06
Chlorid of potassium,	0·77
Chlorid of magnesium,	3·67
Bromid of magnesium,	0·03
Sulphate of magnesia,	2·29
Sulphate of lime,	1·41
Carbonate of lime,	0·03
	1000·00

Recently, Mr. G. Wilson has detected fluorine in sea-water, showing that all the ingredients of coral are actually contained in the waters of the ocean.‡

It has been common to attribute the origin of the lime of corals to the existence of carbonic acid springs in the vicinity of coral islands. But it is an objection to such a hypothesis, that in the first place the facts do not require it; and in the second, there is no foundation for it. The islands have been supposed to rest on volcanic summits, thus making one hypothesis the basis of another. Carbonic acid springs are by no means a universal attendant on volcanic action. The Pacific affords no one fact in support of such an opinion. There are none on Hawaii, where are the most active fires in Polynesia; and the many explorations of the Society and Navigator Islands have brought none to light. Some of the largest reefs of the Pacific, those of New Holland and New Caledonia, occur where there is no evidence of former volcanic action.§

The currents of the Pacific are constantly bearing new supplies of water over the growing coral beds, and the whole ocean is thus engaged in contributing to their nutriment. Fish, molluscs, and zoophytes are thus provided with earthy ingredients for their calcareous secretions, if their food fails of giving the necessary amount; and by means of the powers of animal life, bones, shells, and corals alike are formed.

The origin of the lime in solution throughout the ocean is an inquiry foreign to our present subject. It is sufficient here to show that this lime, whatever its source, is adequate to explain all the results under consideration.

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* On Comparative Analytical Researches on Sea-water, by Prof. Forchhammer, —Rep. Brit. Assoc. for 1846, p. 90.

† Lond. and Ed. Phil. Mag. for July, 1839, xv, 51; Amer. Jour. Sci., xxxviii, 12.

‡ Trans. Roy. Soc. of Edinburg, xvi, 145, 1846; Am. Jour. Sci., 2d ser., ii, 114, 1846.

§ See also Darwin, op. cit., p. 60.

3. *Causes influencing the Growth of Coral Zoophytes.*

Marine zoophytes generally require pure ocean water, and they abound especially in the broad inner channels among the reefs, or the large lagoons, and in the shallow waters outside of the breakers. In these channels at the Feejee Group, there are species of every genus, and they grow in the greatest luxuriance, exceeding in profusion and display, all that was elsewhere seen in the Pacific. Here are found the huge Astræa domes, the Meandrinas, Porites, the leafy clusters of the Merulinæ, numerous Madrepores;—indeed nearly all the Pacific corals described in the Report on Zoophytes, exclusive of those from the Tahitian and Hawaiian Islands, were obtained from the inner reefs of the Feejees.* It is therefore an assertion wide from the fact that only smaller corals grow in the lagoons and channels, though true of lagoons and channels of small size, or of such parts of the larger channels as immediately adjoin the mouths of fresh-water streams.

There are undoubtedly species especially fitted for the open ocean; but as peculiar conveniences are required for the collection of zoophytes outside of the line of breakers, we have not the facts necessary for an exact list of such species. From the very abundant masses of Astræas, Meandrinas, Porites, and Madreporas thrown up by the waves on the exposed reefs, it was evident that these genera were well represented in the outer seas. In the Paumotus, the single individuals of Porites lying upon the shores were at times six or eight feet in diameter. Around the Duke of York's Island the bottom was observed to be covered with small branching and foliaceous Madrepores, (Manoporæ,) as delicate as any of the species in more protected waters.

Species of the same genera grow in the face of the breakers, and some are identical with those that occur also in deeper waters. Numerous Astræas, Meandrinas and Madreporas grow at the outer edge of the reefs where the waves come tumbling in with their full force. There are also many Milleporas and some Porites and Pocilloporas in the same places. But the weaker Manoporas, excepting incrusting species, are found in stiller waters either deep or shallow. The Nullipores, properly calcareous vegetation, flourish best along the line of breakers and form thick accumulations upon the reef.†

Again, the same genera occur in the shallow waters of the reef inside of the breakers. Astræas, Meandrinas and Pocil-

* The author's observations on the *species* of corals were not commenced till reaching the Feejees, where we were among the *inner* reefs. Previous to that time, this department in Zoology was in the hands of Mr. J. P. Couthouy.

† Porites and Milleporæ, according to Mr. Darwin, prevail on the surf-reef of Keeling's Island. Chamisso states that the large Astræas live and grow in the breakers.

loporas are not uncommon, though requiring pure waters. There are also Madreporas, some growing even in impure waters. One species was the only coral observed in the lagoon of Honden Island (Paumotus), all others having disappeared owing to its imperfect connection with the sea. Upon the reefs enclosing the harbor of Rewa, (Viti Lebu,) where a large river three hundred yards wide empties, which during freshets enables vessels at anchor two and a half miles off its mouth to dip up fresh water alongside, there is a single porous species of Madrepora, (M. cribripora,) growing here and there in patches over a surface of dead coral rock or sand. In similar places about other regions, species of Porites are most common. In many instances, the living Porites were seen standing six inches above low tide, where they were exposed to sunshine and to rains; and associated with them in such exposed situations, there were usually great numbers of Alcyonia and Xeniæ. Porites also occur in the impure waters adjoining the shores; and the massive species in such places commonly spread out into flat disks, the top dying from the deposition of sediment upon it.

The exposure of six inches above low tide, where the tide is six feet, as in the Feejees, is of much shorter duration than in the Paumotus, where the tide is less than half this amount; and consequently the height of growing coral, as compared with low tide level, varies with the height of the tides. The powers of endurance in some coral zoophytes cannot surprise us, for it is well known that these animals are often very tenacious of life. The hardier species belong mostly to the genera Porites and Pocillopora, besides the family Alcyonidæ.

The small lagoons, when shut out from the influx of the sea, are often rendered too salt for growing zoophytes, in consequence of evaporation,—a condition of the lagoon of Enderby's Island.

Coral zoophytes sometimes suffer injury from being near large fleshy Alcyonia, whose crowded drooping branches lying over against them, destroy the polyps and mar the growing mass. But Serpulas, and certain species of barnacles constituting the genus Criseis, fix themselves upon the living Astræa, Millepora, and other corals, and finally become imbedded by the increase of the zoophyte, without producing any defacement of the surface, or affecting its growth. Many of these Serpulas grow with the same rapidity as the zoophyte, and finally produce a long tube, which penetrates deep within the coral mass; and, when alive, they expand a large and brilliant circle or spiral of delicate rays, making a gorgeous display among the coral polyps. Instinct seems to guide these animals in selecting those corals which correspond with themselves in rate of growth; and there is in general a resemblance between the markings of a Criseis and the character of the radiations of the Astræa it inhabits.

The effects of sediment on growing zoophytes are strongly marked, and may be often perceived when a mingling of fresh water alone produces little influence. We have mentioned that the Porites are reduced to flattened masses by the lodgment of sediment. The same takes place with the hemispheres of Astræa; and it is not uncommon that in this way large areas at top are deprived of life. The other portions still live unaffected by the injury thus sustained. Even the Fungiæ, which are broad simple species, are occasionally destroyed over a part of the disk through the same cause, and yet the rest remains alive. Wherever streams or currents are moving or transporting sediment, there no corals grow; and for the same reason we find no living zoophytes upon sandy or muddy shores.

The influence of *temperature* on the development of animal life, and the distribution of species is well known. But in no department is it more strikingly displayed than in that of zoophytes. In a former report we have considered the general influence of temperature on the several divisions of this order of animals. The remarks which follow are consequently confined to the *reef-forming* species. We reserve for still another page the influence of this cause on the distribution of reefs, since we are occupied here with zoophytes as animal species, and not with reefs, a result from the growth of corals.

The temperature of the ocean in which reef-corals grow is evidently the temperature congenial to them. From a general survey of facts, it appears that these species are not met with where the winter temperature remains much time below 66° F., though a temporary reduction to 64°, or perhaps lower, (as the Bermudas,) may sometimes occur. Where the temperature is above this, even in the hottest parts of the torrid zone, coral zoophytes thrive well. An isothermal line, crossing the ocean where this winter-temperature of the sea is experienced, one north of the equator, and another south, bending in its course by divergence or convergence, wherever the marine currents change its position, will include all the growing reefs of the world; and the area of waters may be properly called the *coral-reef seas*. This *limiting* temperature is found near latitude 28°. Under the equator in the Pacific, the waters where warmest, have the temperature 85° F., and in the Atlantic 83° F.; 66° to 85° is therefore not too great a range of temperature for the various reef-forming corals. Particular species, however, have smaller limits; but these limits have not yet been accurately ascertained.*

* The first application of the well-established principle that temperature influences the growth and distribution of corals is claimed by Mr. J. P. Couthouy equally with myself. Any attempt, however, to determine a limiting temperature he disclaims, and in this particular, as well as the conclusions arrived at, our views are very different. The facts and inferences stated in this place, and on a following page, are deduced throughout from my own study and investigation.

The Porites and Pocilloporæ predominate at Oahu, (Sandwich Islands,) and there are but few of the Astræidæ,—a fact which appears to be explained on the ground that the reefs of that island are not far from the *cold* limits of the coral seas: and it is interesting to observe that these same corals are the hardiest under exposure to impure waters. The warmest parts of the ocean are favorable to the growth of Astræas, Meandrinas, and the allied species; and at the same time, these regions abound in Porites and Pocilloporæ, although the proportion of these corals is smaller than at Oahu.

The genera of reef-forming corals which occur out of the coral-reef seas, belong almost exclusively to the Caryophyllia family, and especially to the genera Dendrophyllia, Caryophyllia, Astroides,* Oculina, and Cyathina, some species of which exist in the Norwegian seas. The Gorgonidæ, Alcyonidæ, Hydroidea, and Actinidæ, extend from the equator nearly to the frigid zone. The Bryozoa have an equally wide range.†

The liability of the lagoons, when contracted in size, to become highly heated by the sun, is probably one cause leading to the depopulation of these internal waters. The temperature becomes raised, as in a puddle of standing water elsewhere, and is quite unfitted, therefore, for species accustomed only to the ordinary tropical temperature of the ocean.

Light and *pressure* and probably the amount of air in seawater, influence the growth of corals, so far as to fix limits to their distribution in *depth*. It is a little remarkable that those families which have a wide geographical range, have also a great range in depth: for Caryophylliæ, Dendrophylliæ, Oculinæ, Gorgonidæ, and Hydroidea, are found even at depths of one or two hundred fathoms; while Madrepores and Astræas, and all the ordinary reef-forming species scarcely exceed a depth of twenty fathoms.

Temperature has little or no influence in determining this range, although it has been so asserted: 66° is not met with under the equator short of 75 or 100 fathoms. The following table gives approximate results for the winter months, from observations on this point by different navigators in the Pacific. It is well known that these averages are varied much in particular regions by currents.

Latitude.		Depth of 6° Fahrenheit.
N. Latitude.	28°—30′	0—25 fathoms.
	25°	25—30 "
	20°	30—50 "

* The corals of the Astroides closely resemble those of the Astræa, and have been referred to the latter group by many authors. A related species is found on the coast of this country as high up as lat. 42. An Astræa has been reported from Sydney, New South Wales, which, if a true Astræa, (it has not been described or figured,) gives this genus a wider limit than the coral reef seas.

† See farther, Report on Zoophytes, p. 102.

	Latitude.	Depth of 6° Fahrenheit.
	15°	40—60 fathoms.
	10°	50—75 "
	5°	75 "
Equator.	0°	75—100 "
S. Latitude.	5°	50—75 "
	10°	50 "
	15°	50 "
	20°	40 "
	25°	25 "
	28°—30°	Surface.

It appears, therefore, that among the causes limiting the range of corals in depth, light and hydraulic pressure must have great influence. The proportion of atmospheric air present may be another cause. Yet according to Darondeau, the deeper waters contain more atmospheric air and also more carbonic acid,—the difference being as much as $\frac{1}{160}$th the volume of the water.*

Quoy and Gaymard were the first authors who ascertained that reef-forming corals were confined to small depths, contrary to the account of Forster and the early navigators. The mistake of previous voyagers was a natural one, for coral reefs were proved to stand in an unfathomable ocean; yet it was from the first a mere opinion, as the fact of corals growing at such depths had never been ascertained. It is now considered altogether probable that the bottom of the ocean in its deeper parts is mostly without life of any kind. The few Caryophylliæ and other species which are met with in deep waters, have been shown to be sparsely scattered, mostly of small size, and nowhere form accumulations or beds.

The above-mentioned authors, who explored the Pacific in the Uranie under D'Urville,† concluded from their observations that five or six fathoms (30 or 36 feet) limited their downward distribution. Ehrenberg, by his observations on the reefs of the Red Sea, confirmed the observations of Quoy and Gaymard; he concluded that living corals do not occur beyond six fathoms. Mr. Stutchbury, after a visit to some of the Paumotus and Tahiti, remarks that the living clumps do not rise from a greater depth than 16 or 17 fathoms.‡ Mr. Darwin, who traversed the Pacific with Captain Fitzroy, R. N., gives 20 fathoms as not too great a range, and mentions reported instances of growing reefs in 25 or even 30 fathoms. He states that in the Red Sea, according to Captain Morehead, living corals occur at 25 fathoms. At Keeling Atoll, growing corals are described by him as wholly disap-

* Examination of Sea Water collected during the Voyage of the Bonite, Jameson's Edinb. Jour., July, 1838, p. 164. Darondeau's observations require confirmation.

† Afterwards also in the Astrolabe.

‡ S. Stutchbury, West of England Journal, i, 48.

pearing beyond 20 fathoms; and at the Maldives and Chagos, at a less depth. Other facts brought forward by Mr. Darwin, relate to Caryophylliæ and those species which have a wide range beyond reef-forming zoophytes.

It thus appears that all recent investigators since Quoy and Gaymard have agreed in assigning a comparatively small depth to growing corals. The observations on this point, made during the cruise of the Expedition, tend to confirm this opinion. The conclusion is borne out by the fact that soundings in the course of the various and extensive surveys afford no evidence of growing coral beyond twenty fathoms. Where the depth was fifteen fathoms, coral sand and fragments were almost uniformly reported. Among the Feejee Islands, the extent of coral reef-grounds surveyed was many hundreds of square miles, besides the more careful examination of harbors. The reefs of the Navigator Islands were also sounded out, with others at the Society Group, besides numerous coral islands; and through all these regions no evidence was obtained of corals living at a greater depth than 15 or 20 fathoms. Within the reefs west of Viti Lebu and Vanua Lebu, the anchor of the Peacock was dropped sixty times in water from 12 to 24 fathoms deep, and in no case struck among growing corals; it usually sunk into a muddy or sandy bottom. Patches of reef were encountered at times, but they were at a less depth than 12 fathoms. By means of a drag, occasionally dropped in the same channels, some fleshy Alcyonia, and a few Hydroidea were brought up, but no reef-forming species.

Outside of the reef of Upolu, corals were seen by the writer growing in twelve fathoms. Lieutenant Emmons brought up with a boat-anchor a large Dendrophyllia from a depth of fourteen and a half fathoms at the Feejees; and this species was afterwards found near the surface. Dendrophyllia, it may be remembered, is one of the deep water genera.

These facts, it may be said, are only negative, as the sounding-lead, especially in the manner it is thrown in surveys, would fail of giving decisive results. The character of a growing coral bed is so strongly marked in its uneven surface, its deep holes and many entangling stems, to the vexation of the surveyor, that in general the danger of mistake is small. But allowing uncertainty as great as supposed, there can be little doubt after so numerous observations over so extended regions of reefs.

The depth of the water in harbors and about shores where there is no coral, confirms the view here presented. At Upolu, the depth of the harbors varies generally from twelve to twenty fathoms. On the south side of this island, Lieutenant Perry, off Falealili, one hundred yards from the rocky shores, found bare rocks in eighteen and nineteen fathoms, with no evidence of coral. There is no cause here which will explain the absence of

coral, except the depth of water; for corals and coral reefs abound on most other parts of Upolu. Below Falelatai, of the same island, an equal depth was found, with no coral. Off the east cape of Falifa harbor, on the north side of Upolu, Lieutenant Emmons found no coral, although the depth was but eighteen fathoms. About the outer capes of Fungasar harbor, Tutuila, there was no coral, with a depth of fifteen to twenty fathoms; and a line of soundings across from cape to cape, afforded a bottom of sand and shells, in fifteen to twenty-one and a half fathoms. About the capes of Oafonu harbor, on the same island, there was no coral, with a depth of fifteen fathoms.

Similar results were obtained about all the islands surveyed, as the charts satisfactorily show. There is hence little room to doubt that twenty fathoms may be received as near the range in depth for reef corals; and probably the limit lies between fifteen and twenty fathoms, or not far from one hundred feet.

It may be here remarked, that soundings with reference to this subject are liable to be incorrectly reported, by persons who have not particularly studied living zoophytes. It is of the utmost importance, in order that an observation supposed to prove the occurrence of living coral should be of any value, that it be unequivocally determined whether the fragments which a lead may bring up are alive or not when broken off; for a dead fragment proves nothing. Even a strong impression upon the lead, showing the form and character of the surface-cells of a coral, is not wholly satisfactory, as it may have been given by a mass not living. A living fragment, placed in water, will be seen to have a fleshy surface, even if the polyps do not expand. The best observations with reference to this subject would be made with a diving bell.

Much yet remains for farther investigation. Mr. Edward Forbes, in his Zoological Explorations of the Ægean, distinguished three separate regions of invertebrate species within twenty fathoms of the surface: the *first*, or littoral, extending to two fathoms in depth; the *second* from two to ten fathoms; the *third* from ten to twenty fathoms.* Similar subdivisions, or others on the same general principle, may yet be detected in the Pacific, indicated perhaps by zoophytes as well as molluscs. There is no evidence, however, that there are successive beds, composed of a distinct set of species, as has been sometimes suggested. The upraised reefs of Metia afford no proofs of such a mode of formation; on the contrary, they show that the process is continuous and uniform in character through the reef-growing depths. The species in the lower part of the sixteen fathoms are probably different from many of those above; but they pertain to the same gen-

* On the Ægean Invertebrata, E. Forbes, Rep. Brit. Assoc. for 1843, p. 154.

era in most instances, and moreover there are no abrupt transitions; consequently the resulting reefs should have a nearly uniform character, as here stated. This fact may be better appreciated after perusing the following chapter.

The Nullipore zone along the reef-line between low and high tide, is clearly made out by Mr. Darwin, and is one of the interesting results of his investigations. It performs a very important part, by the protection it gives the reef from abrasion. The exposed reef is thus gathering lime from the waters, and extending itself, when, if devoid of this protection, it would be constantly yielding to the sea. On the inner reefs where the protection is not needed, it is not given; some species of Nullipore, however, occur in these regions, and others are found at various depths.

As the Caryophyllia family extend into deeper waters than most other reef-corals, it might be inferred that these at least may constitute a lower bed, or substratum. But this is by no means the case. As just stated, one species (the Dendrophyllia nigrescens) was found at 14½ fathoms and also of identical characters at low tide level. The Caryophylliæ are but sparingly distributed; the species are few, and mostly small; and not a dozen different kinds were detected in the Pacific. Their contributions to reefs are therefore inconsiderable.

4. *Rate of Growth of Zoophytes.*

The rate of growth of zoophytes, is a subject but little understood. We do not refer here to the progress of a reef in formation, which is another question complicated by many co-operating causes; but simply to the rapidity with which particular species of coral-zoophytes increase in size. There is no doubt that the rate is different for different species. It is moreover probable that it corresponds with the rate of growth of other allied polyps that do not secrete lime. The rate of growth of Actiniæ might give us an approximation to the rate of growth in a Mussa, which are coral animals of like size and general characters; for the additional function of secreting lime, would not retard necessarily the maturing of the polyp; and from the rate of growth of the same animals in the young state, we might perhaps draw some inferences as to the rate in polyps of corresponding size. But no observations on this point were made by us while abroad.

Although the rapidity is undoubtedly far less than was formerly reported, the following facts from different sources seem to show that the rate is still greater than has been of late believed. Mr. Darwin, citing from a manuscript by Dr. Allen of Forres, some experiments made on the east coast of Madagascar, states that, in December, 1830, twenty corals were placed by this gentleman apart on a sandbank, in three feet water, (low tide,) and

in the July following, each had nearly reached the surface, and was quite immovable; and some had grown over the others. Mr. Stutchbury describes a specimen consisting of a species of oyster, whose age could not be over two years, encrusted by an Agaricia, weighing two pounds nine ounces.* It is stated by M. Duchassaing, in a letter from Guadeloupe, that in two months, some large individuals of the *Madrepora prolifera*, which he broke away, were restored to their original size.†

Since the return of the Expedition, I have received a letter containing some facts on the growth of Actiniæ from Sir J. G. Dalyell, whose able observations in this department of science are highly curious and important. After speaking of the various conditions and sizes of the young at birth, and of the difference in the rapidity of growth depending on the amount of nutriment at hand, he says, speaking of a Scottish species of Actinia, "The dimensions will generally double in a fortnight from its birth. The diameter of the base being originally about an eighth of an inch, or hardly as much, will be five-eighths in six months, and the tentacles will occupy a circle of an inch and a half in diameter. In twelve or thirteen months, the diameter of the base will reach an inch and the expansion of the tentacles two inches between the tips. An Actinia whose tentacula expanded a quarter of an inch three weeks after it was produced, enlarged so much in five months that they expanded an inch, and the body was then half an inch thick." If we reason upon these data, and assume that the Madrepore polyps may increase lineally in six months as much as the young Actinia, we shall have an elongation of five-eighths or three-fourths of an inch in six months. Taking the still more rapid rate, of doubling in a fortnight, which might be more correct, since the Madrepore polyps are about the size of the Actinia in its earliest state, we should have a lengthening of a fourth of an inch in a month, and three inches a year. The data upon which this conclusion is based, though important, are uncertain, but would probably give too high rather than too low an estimate. And yet it is far below the rate apparently established by the experiments with corals cited in the preceding paragraph. We must admit that the subject requires more accurate investigation.

The stay of the expedition near any particular reef in the Pacific was too short for any examinations by us. They might easily be made by those residing in coral seas, either in the manner adopted by Mr. Allan, or more definitely by placing marks upon particular species. By inserting slender glass pins a certain distance from the summit of a Madrepore, its growth might be

* West of England Journal, vol. i, p. 50,

† L'Institut, No. 639, April 1, 1846, p. 111.

accurately measured from month to month. Two such pins in the surface of an Astræa, would in the same manner, by the enlarging distance between, show the rate of increase in the circumference of the hemisphere; or if four were placed so as to enclose an area, and the number of polyps counted, the numerical increase of polyps resulting from budding, might be ascertained. It is to be hoped that some of the foreign residents at the Sandwich, Society, Samoan or Feejee Islands will take this subject in hand. There are also many parts of the West Indies, where these investigations might be conveniently made.

The applications of the facts reviewed occupy us in our next chapter.

ART. XX.—*On the Flow of Elastic Fluids through Orifices; with a suggestion of a new method of determining the mutual relations of Elastic Force, Temperature and Density in an Expanding Fluid;* by ELI W. BLAKE.

IN volume v, Second Series, of this Journal, page 78, I proposed a new theory of the flow of elastic fluids through orifices, differing essentially from that heretofore received. The chief object of the present article is to give an account of an experiment instituted for the purpose of testing the truth of that theory.

The fundamental points of difference between the old theory and the new, are as follows:—

1. The old theory regards the constant force which expels the fluid as being, in all cases, equal to the difference between the elastic forces of the fluids in the two vessels.

The new theory regards it as equal to that difference only when the less exceeds half the greater; and in all other cases as equal to half the greater.

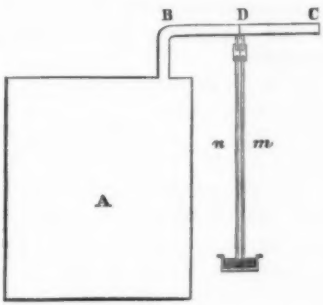
2. The old theory considers the fluid as passing the orifice with a density equal to that in the *discharging* vessel.

The new theory considers it as passing the orifice with a density equal to that in the *receiving* vessel, whenever this last is equal to or greater than half the density in the discharging vessel; and in all other cases, with half the density in the discharging vessel.

The formula for the quantity discharged in a given time, predicated upon the new theory, gives, in all cases, less than that predicated upon the old theory. In the case of a flow into a vacuum, the difference amounts to one half.

The scheme devised to test the relative merits of the two theories, was founded upon the following considerations, viz.: When air rushes from the atmosphere into a receiver wholly or partially exhausted, passing on its way through a small intermediate vessel or chamber, entering that chamber and passing out

of it through equal orifices, it will take in that chamber a density somewhere intermediate between that of the atmosphere and that in the receiver. For each relation that may at any moment subsist between the density of the atmosphere and that in the receiver, the density in the chamber will have a certain definite and determinate value, such that the chamber may receive through one orifice and discharge through the other simultaneously the same quantity of air. Now since in order to this equal simultaneous flow the two theories respectively demand quite different densities in the chamber, the object of my experiment was to ascertain the actual densities in such a chamber under various relations of the density in the receiver to the density of the atmosphere, in order to compare the densities thus ascertained experimentally with those demanded by each theory respectively in like circumstances.



To try the experiment, I constructed the apparatus shown in the annexed sketch. A is a vessel or receiver of the capacity of about 50 gallons, so arranged that it may be exhausted by the air-pump or otherwise. B is an elbow formed of lead pipe of one inch calibre, one branch of which opens into the receiver, and the end of the other branch at C is covered by a brass plate or disc about $\frac{1}{16}$th of an inch in thickness, through which is an orifice of about $\frac{1}{16}$th of an inch in diameter. Another similar plate with an orifice of the same size intersects the pipe at D, thus forming a chamber between the two plates. Two short tubes are inserted into the lower side of the pipe; one on each side of the plate D. With these short tubes two glass tubes *m* and *n*, each thirty-three inches in length, are connected by means of pieces of India rubber hose. These glass tubes are open at both ends and terminate at the bottom in a vase of mercury. A rod (not shown in the sketch) graduated to inches and tenths is placed beside the glass tubes, sustained upon a float resting upon the surface of the mercury, so adjusted that zero of the graduation may coincide with the surface of the mercury.

If the orifice at C be closed by a stopper and the receiver exhausted, the mercury will rise in the tubes; and if the density of the atmosphere at the time of the experiment be expressed in inches of mercury, the height of the mercury in the tubes as read upon the graduated rod will be equal to the difference between the density of the atmosphere and that in the receiver. If

we now remove the stopper from the orifice at C, the column of mercury in the tube *m* will instantly subside to a point which indicates the difference between the density of the atmosphere and the density in the chamber when an equal quantity of air flows through the two orifices; while at the same time the column of mercury in the tube *n* will only have *began* to subside very slowly as the density in the receiver increases. Having noted the height of the barometer at the time of the experiment, if we note the simultaneous heights of these two columns of mercury, and deduct them respectively from the height of the barometer, we shall have the density in the chamber necessary to an equal flow through the two orifices under the relation which subsists at the moment of notation between the density in the receiver and the density of the atmosphere. And if we note the simultaneous heights of these columns at various times during the filling of the receiver, so many densities in the chamber shall we find corresponding to different relations of the other two densities.

At the time of the experiment the height of the barometer, or density of the atmosphere was thirty inches. In consequence of leaks in the receiver, I was unable to exhaust it so as to raise the column in the tube *n* higher than twenty-six inches. I noted the simultaneous altitudes of the two columns at the moment when the column *n* coincided with each successive inch-mark upon the graduated rod, and thence ascertained the densities in the chamber under twenty-six different relations between the density in the receiver and that of the atmosphere. These results I have placed in the table beyond, in which the first column shows the densities in the receiver at the times of notation, and the second the densities in the chamber corresponding thereto.

In order to ascertain what these densities should have been according to the old theory, I constructed a formula as follows. Let Δ be the height of the barometer at the time of the experiment, D the density in the receiver, d the density in the chamber, V the velocity through the first orifice, v the velocity through the second orifice. Then according to the old theory the force which drives the air through the first orifice is $\Delta - d$ and that which drives it through the second orifice is $d - \mathrm{D}$. But since an equal quantity flows through both, these forces are as the velocities, that is $\Delta - d : d - \mathrm{D} :: \mathrm{V} : v$.

Again, according to the old theory the density with which the air passes the first orifice is Δ, and that with which it passes the second orifice is d. But since the orifices are equal and the quantities which pass through them are also equal, the products of the velocities by the densities are equal, that is $\Delta \mathrm{V} = dv$ and $\mathrm{V} = \frac{dv}{\Delta}$.

Substituting this value of V in the preceding couplet and then finding the value of d, we have the following formula for determining the densities in the chamber according to the old theory, viz.,

$$d=\sqrt{\Delta^2+\frac{\overline{\Delta-\mathrm{D}}|^2}{4}}-\frac{\Delta-\mathrm{D}}{2}.$$

The several densities in the chamber computed by this formula are placed in the fourth column of the table.

In order to ascertain what the densities in the chamber should have been according to the new theory, I constructed a formula as follows, preserving the same notation as above.

By the new theory the force which drives the air through the first orifice is $\Delta-d$ whenever d is not less than $\frac{\Delta}{2}$. But d is never less than $\frac{\Delta}{2}$ when an equal quantity flows through both orifices, for if it were so the chamber would, according to our theory, be receiving as much as could flow into a vacuum under the pressure Δ, and must therefore discharge into the receiver as much as would flow into a vacuum under a pressure Δ; in order to which the density in the chamber must be equal to Δ, and therefore greater than $\frac{\Delta}{2}$. Consequently, the force which drives the air through the *first* orifice is in this arrangement always $\Delta-d$. Again, the force expended in driving the air through the second orifice by the new theory is $\frac{d}{2}$ whenever D is not greater than $\frac{d}{2}$. Let us first construct a formula for the cases in which D is not greater than $\frac{d}{2}$. In these cases the densities under which the air passes the orifices are respectively $\Delta-d$ and $\frac{d}{2}$. Since the forces are as the velocities, $\Delta-d:\frac{d}{2}::\mathrm{V}:v$; and since the quantities are equal, $d\mathrm{V}=\frac{dv}{2}$, and $\mathrm{V}=\frac{v}{2}$. Substituting this value of V in the couplet, we have $d=\frac{4}{5}\Delta$; a constant quantity. Hence while the density in the receiver varies from 0 to $\frac{2}{5}\Delta$, the density in the chamber is a constant quantity and equal to $\frac{4}{5}\Delta$. Let us now construct a formula for finding the value of d when D is greater

than $\frac{d}{2}$. In these cases the forces are $\Delta - d$ and $d - D$ and we have for the couplet $\Delta - d : d - D :: V : v$. The densities in the orifices are d and D, and we have $dV = Dv$ and $V = \frac{Dv}{d}$. Substituting this last quantity in the couplet we find

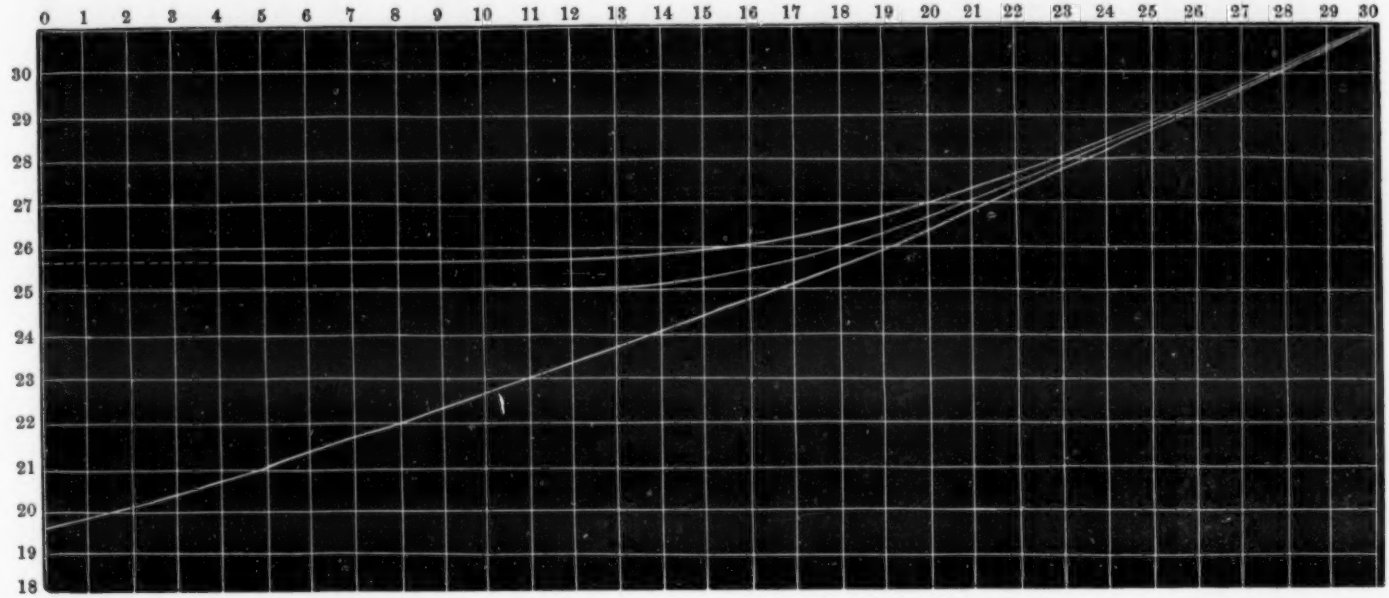
$$d = \sqrt{D^2 + \frac{\overline{\Delta - D}^2}{4}} + \frac{\Delta - D}{2}$$

as the formula for the value of d by the new theory when D exceeds $\frac{2}{5}\Delta$. The densities in the chamber computed by these formulæ are placed in the third column of the table.

Density of the Atmosphere during Experiment 30.

Density in the receiver.	Density in the chamber as found by experiment.	Density in the chamber due to the new theory.	Density in the chamber due to the old theory.	Deviation of the experiment from the new theory.
0		24	18·541	
1		24	18·820	
2		24	19·106	
3		24	19·397	
4	24·58	24	19·695	·58
5	24·58	24	20	·58
6	24·58	24	20·311	·58
7	24·58	24	20·628	·58
8	24·58	24	20·953	·58
9	24·58	24	21·284	·58
10	24·58	24	21·622	·58
11	24·60	24	21·968	·60
12	24·64	24	22·320	·64
13	24·70	24·032	22·713	·668
14	24·77	24·124	23·048	·646
15	24·89	24·270	23·423	·62
16	25·03	24·464	23·805	·566
17	25·21	24·700	24·194	·51
18	25·43	24·974	24·594	·456
19	25·69	25·280	25	·41
20	25·96	25·615	25·414	·345
21	26·30	25·976	25·835	·324
22	26·65	26·360	26·265	·29
23	27·03	26·764	26·699	·266
24	27·43	27·186	27·149	·244
25	27·81	27·625	27·604	·185
26	28·20	28·076	28·066	·124
27	28·65	28·541	28·533	·109
28	29·08	29·017	29·016	·063
29	29·55	29·504	29·504	·046
30	30	30	30	

The affinity of the experimental results to those derived from the new theory, is obvious upon inspection of the table; and the want of affinity to those derived from the old theory, is not less evident. The comparative relation of the two theories to the results of experiment, is more readily seen in the annexed cut,



Numbers at top represent the densities in the receiver; those on the side, densities in the chamber.

where they are respectively delineated by a curve. The upper curve represents the densities or elastic forces in the chamber, as found by experiment; the next curve those due to the new theory, and the lower curve those due to the old theory.

Notwithstanding the near approximation of the experimental results to those due to the new theory, there is yet a small but distinct deviation, which holds throughout. This deviation indicates either that there is some cause affecting the flow which the theory does not take into the account, *or* that in the structure of the apparatus or in trying the experiment, there was some failure to comply with the requisite conditions.

Although the apparatus was rude in its structure, yet care had been taken to secure a compliance with the conditions on which the experiment was based; and in conducting the experiment I was assisted by my friend, Prof. A. C. Twining, a gentleman distinguished for his accuracy in such matters. The experiment, moreover, was several times repeated, with no important difference in the results. For these reasons, in seeking the cause of the deviation, my first inquiry was whether it might be attributed to a change in the ratio of elastic force to density; the theory being predicated on the assumption that this ratio is constant. It has been ascertained by experiment, that when air is condensed and then suffered to lose the heat evolved by condensation, the ratio of its elastic force to its density will be diminished. Hence it is certain that a part or the whole, or possibly even more than the whole heat evolved by condensation will be required to prevent that ratio from being diminished. Still, however, it has generally been assumed by philosophers (I know not on what grounds) that if air is *suddenly* condensed, so as not to allow the heat evolved by condensation to escape, the ratio of elastic force to density will be *increased*. This assumption was made by Laplace when he attributed to this cause, in part, the velocity of sound. Let us suppose then, for the present, that in sudden condensation the ratio of elastic force to density is *increased*. It will then follow that in sudden *expansion*, the ratio of elastic force to density will be *diminished*. But if that ratio were diminished, then the deviation in the table should be in the opposite direction; that is, the experimental results, instead of being greater than the theoretical, should be less. The deviation, therefore, is not accounted for by this supposition; on the contrary, the experiment seems to prove that the ratio is not diminished by expansion, and therefore cannot be increased by condensation, as Laplace supposed.

Let us next take the contrary supposition, viz., that the ratio of elastic force to density is *increased* by expansion. This would cause a deviation in the same direction as we find in the table. In order to ascertain whether the deviation in question is due to this cause, we must next inquire whether a deviation arising from

this cause, would vary in the same manner throughout the table, as does the observed deviation. Now if we go through the table and assign for each observation severally, the manner in which the ratio of elastic force to density must increase, in order to satisfy that observation, we shall find very nearly one and the same increment of the ratio demanded for all the observations. Hence if we attribute the deviation to this cause we should be obliged to conclude that one and the same change in the ratio takes place, whether the expansion be greater or less. But such a conclusion is obviously inadmissible. We cannot, therefore, attribute the deviation in question to a change in that ratio, either by increase or diminution.

Nor can we ascribe the deviation to that which is the chief cause of deviation from theory in the case of the flow of *liquids*, viz., the contraction of the stream in passing an orifice. For if that cause operated, it would affect the flow in the same ratio in both orifices, and therefore would not, in this case, affect the indications of the mercurial columns. Moreover, I think it can be shown, from considerations *a priori*, that the cause which produces the contraction of the stream in liquids, could not operate to affect the flow of expansible fluids.

Having satisfied myself that the deviation was not due to the causes above named, my next inquiry was, whether a difference in the sizes of the orifices (hitherto assumed to be equal) would cause a deviation corresponding to that in the table. In examining this point, I found that the experimental results would be very nearly satisfied throughout the table, by the assumption that the area of the second orifice was less than that of the first, in about the ratio of ·933 to 1. As the two orifices had been made as nearly equal as they could be by forcing the same steel plug through both, I was confident that, as originally formed, they could not differ to this extent. But it occurred to me that some accidental circumstance might have occurred to diminish the inner orifice, and I suspected that the workman, in handling the brass plate after the orifice was made, had got dirt into it, and had omitted to cleanse it before soldering on the outer plate. To ascertain whether such was the case, I divided the tube near the second orifice, and, upon examining it with a microscope, discovered that there was dirt adhering around its inner periphery sufficient, I think, to cause a diminution of its area to the extent above named. Unfortunately this discovery was made after the arrangements for trying the experiment had been removed; and I have not since found leisure to replace them and try the experiment anew. But for this accidental circumstance no doubt there would have been a still nearer approximation of the experimental results to those derived from the formula. The coincidence, however, is sufficiently near to establish the truth of the new

theory, so far as respects those points of difference between the two theories specified in the first part of this article.

The fifth column of the table shows the several differences between the experimental results, and those due to the new theory. It will be noticed that these differences increase slightly between density 10 and 13 in the receiver, before they begin to decrease. This, I think, indicates a slight obstruction to the flow through the second orifice, when the density in the receiver becomes equal or nearly equal to that of the effluent stream. This increment at its maximum amounts to ·088, corresponding to the pressure of that portion of an inch of mercury, and is, I think, the measure of the obstruction or resistance due to that circumstance. If this view of the subject is correct, then there would have been a deviation to this extent in this part of the table, even if the orifices had been equal.

It is desirable that further experiments of this kind should be tried by those who have better means at command than I had to do justice to the subject. To such as may be disposed to undertake it, I would suggest that a perfect equality of the two orifices might be secured by interchanging the discs, varying the sizes of the orifices until they gave the same indications in both positions.

If, after thus securing the equality of the orifices, there should still be a deviation in that part of the table where the elastic force in the chamber is constant, such deviation, I think, must be attributed to a change in the ratio of elastic force to density; and if so, its amount would furnish the means of determining the law according to which that ratio varies.

I would also suggest that a modification of this experiment would furnish perhaps the best possible means of determining the law according to which the ratio of elastic force to *temperature* varies, when the absolute amount of heat is constant. In an arrangement for this purpose, the bulb of a thermometer should be inserted into the chamber; and the outer orifice should be so constructed that it may be enlarged or diminished at pleasure. With this arrangement, we may cause the air in the chamber to assume, almost instantly, any elastic force we may choose, between the elastic force of the atmosphere, and a little more than twice the elastic force in the receiver; and we may keep that force *constant* in the chamber during any time that may be required to cool the thermometer down to the corresponding temperature, the continual flow through the chamber in the mean time carrying off not only the heat which flows in from extraneous sources, but also that derived from the thermometer itself. We may thus ascertain the relation of elastic force to temperature at as many points as we please within this range, and thereby determine the law of their variation when the absolute amount of heat remains constant.

ART. XXI.—*On the Relation of the Chemical Constitution of Bodies to Taste;* by Prof. E. N. HORSFORD, of Harvard.*

PROF. HORSFORD alluded to a paper upon Glycocoll published in 1846, in which he called attention, in a note, to the interesting relation sustained by that body in its chemical constitution, to other sweet bodies, and cited the following formulæ:

$C_4H_3\overset{H}{\underset{N}{}}O_3$ = Glycocoll. $C_4H_3\overset{H}{\underset{O}{}}O_3 \times 3$ = Grape sugar.

$C_4H_3\overset{Pb}{\underset{O}{}}O_3$ = Sugar of lead. $C_4H_3H\ H_{\frac{2}{3}}^{\frac{2}{3}}O_{\frac{1}{3}}^{\frac{1}{3}}\ O_3 = \frac{2}{3}$ Oxyd of glycerile

To this enumeration of sweet bodies was appended the query, "Is this similar taste dependent upon a similar arrangement of their minutest particles?"

Prof. H. remarked that, early in 1848, he presented to the American Academy of Arts and Sciences, with a modification of the formulæ, an additional list of sweet bodies. Some of the formulæ were arbitrarily doubled from the received fromulæ, and others fractionally reduced, for the sake, merely, of tracing this interesting relationship.

The modification of the formulæ, and the list as then presented, were as follows:

$C_4H_4O_4 \times 3$ = Grape sugar.

$C_4H_2\overset{H}{\underset{O}{H}}O_3$ = Grape sugar. $C_4H_2\overset{H}{\underset{N}{H}}O_3$ = Glycocoll.

$C_4H_2\overset{Pb}{\underset{O}{H}}O_3$ = Sugar of lead. $C_4H_2Pb\overset{O}{\underset{O}{O}}\cdot 3$ = Citrate of lead.

$C_4H_2\overset{O}{\underset{O}{K}}O_3$ = Acetate of potassa. $C_4H_2\overset{H}{\underset{N}{H}}O_3, H, O,$ = Nitric ether,

$C_4H_2H\ H_{\frac{2}{3}}^{H}O_{\frac{1}{3}}\ O_3 \times 1{\cdot}5$ = Oxyd of glycerile.

$C_4H_2Cl\overset{Cl}{\underset{Cl}{Cl}}Cl_3 \div 2$ = Chloroform. $C_4H_2Br\overset{Br}{\underset{Br}{Br}}Br_3 \div 2$ = Bromoform.†

$C_4H_2I\overset{I}{\underset{I}{I}}I_3 \div 2$ = Iodoform. $C_4H_2I\overset{I}{\underset{Cl}{Cl}}Cl_3 \div 2$ = Chloroiodoform.

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* Proceedings of the American Association for the Advancement of Science. Fourth meeting, held at New Haven, Conn., August, 1850.

† For the observation that this and the following four bodies may be included under this type, the author acknowledged his indebtedness to his assistant, Dr. Chas. H. Peirce.

$$C_4H_2\overset{Br}{\underset{I}{Br}}I_3 \div 2 = \text{Bromoiodoform.}$$

$$C_4H_2\overset{H}{\underset{H}{H}}F_2 \div 2 = \text{Hydrofluate of methylene.}^*$$

$$C_4H_2\overset{S}{\underset{S}{S}}S_3 \div 2 = \text{Sulphoform.} \qquad C_4H_2\overset{H}{\underset{H}{H}}Cl_2 \div 2 = \text{Chlorid of methyle.}$$

$$\overset{C_2}{S_2}H_2\overset{O}{\underset{O}{Ag}}O_3, H, O, = \text{Methylsulphite of silver.}$$

$$\overset{C_2}{S_2}H_2\overset{O}{\underset{O}{Pb}}, H, O, = \text{Methylsulphite of lead.}$$

$$\overset{C_2}{S_2Ag}H\overset{O}{\underset{O}{Cl}}O_3, H, O = \text{Chloro-methylsulphite of silver.}$$

$$\overset{C_2}{S_2Pb}H\overset{O}{\underset{O}{Cl}}O_3, H, O = \quad \text{“} \quad \text{“} \quad \text{lead.}$$

$$S_4\overset{O}{\underset{O}{Ag_2}}O_3 \div 2 = \text{Hypo-sulphite of silver.}^\dagger$$

$$S_4\overset{Na}{\underset{Hg}{O}}O_3 = \text{Hypo-sulphite of mercury and soda.}$$

To these Prof. Horsford remarked there might be added

$$C_4H_2\overset{H_2}{\underset{O}{}}O_3 \cdot 3 + H_2 = \text{Mannite; and}$$

$$C_4H_4S_4.$$

Several other compounds of sulphur with C_4H_4 do not taste sweet.

The following sweet bodies, one possessing a multiple and the other nearly a multiple of the number of atoms in glycocoll, do not readily admit of being written in the above formula—

$$C_{10}H_{11}O_3 = 24 = \text{Valerianic acid.}$$
$$C_{16}H_{11}O_7 = 34 = \text{Orcine.}$$

In reply to the inquiry as to whether sweetness may be ascribed to a peculiarity of form, the following facts are of significance:

$C_4H_4S_4$	tastes sweet, and contains		C, H and S.
$C_4H_4O_4$	“	“	C, H and O.
$S_4\overset{O_2}{\underset{Ag_2}{}}O_4$	“	“	neither C nor H.

* This body has a pleasant ethereal smell.

† The correspondence in constitution of this body with the next in succession gives additional interest to the formula.

The taste is, therefore, not dependent upon any one of the elements present, since each may be replaced entirely by another without destroying the taste.

In the communication submitted to the American Academy, attention was directed to the common formula, in which, according to Davy and to most modern chemists, all the acids containing hydrogen may be written, and also the oxygen acids which ordinarily exist in combination with an atom of water, as sulphuric and nitric acids; to wit, $H + x$; in which x represents all that part of the acid not replaced by metal in neutralization. A few examples follow:

$H + Cl$	= Hydrochloric acid.	$H + NO_6$	= Nitric acid.
$H + I$	= Hydriodic "	$H + C_2HO_4$	= Formic "
$H + Br$	= Hydrobromic "	$H + C_2O_4$	= Oxalic "
$H + F$	= Hydrofluoric "	$H + C_4H_3O_4$	= Acetic "
$H + Cy$	= Hydrocyanic "	$H + C_6H_5O_4$	= Metacetonic acid.
$H + SO_3$	= Sulphurous "	$H + C_8H_7O_4$	= Butyric "
$H + SO_4$	= Sulphuric "	$H + C_{10}H_{11}O_4$	= Valerianic " &c.

The inquiry naturally arises, have sour bodies a common *form?* to which, and not to the nature of the constituent particles, the property of sourness is to be attributed. They (the acids) are composed of one larger atom, or group of atoms united to the least atom, hydrogen, easily replaceable by a metal, and bound to the group by an affinity apparently much feebler than that of any of the remaining elements.

An allusion was made, in the communication to the Academy, to the class of resins—some of the soluble members of which possessing a bitter taste—might, according to a research of Heldt upon Santonine, be referred to a single fundamental type. He refers the resins, for their origin, to the oxydation of the essential oils, and though the conception has been entertained by other chemists, it has first met with a full exposition in this paper. The hydrogen of essential oils oxydates, as a general thing, much more readily than the carbon. The following formulæ present Heldt's view of the production of resins. All are derived, he conceives, from $C_{10}H_8$.

$$[C_{10}H_8]^n - Hx + Ox = R.$$
$$[C_{10}H_8]^n - Hx + Ox + (HO)y = R.$$
$$[C_{10}H_8]^n - Hx + Ox + Oy = R.$$
$$[C_{10}H_8]^n - Hx + Ox + Oy = [HO]z = R.$$
$$[C_{10}H_8]^n + [HO]x = R.$$

These formulæ present in the original essential oils, groups of atoms, in which a part of the hydrogen occupies a more exposed situation, if one may employ the illustration, than other parts of the molecule, and oxydates more readily. In this respect there is approximation to a common form, in view of which the in-

quiry was suggested, *may the bitterness be ascribed to this form?* This, however, does not furnish an explanation of the remarkable bitterness of the organic bases.

Guided by the above suggestion, Prof. H. remarked, let the conception be entertained that the alkaloids have been derived from the greater or less oxydation of bodies having the general constitution of the essential oils, and the replacement of three atoms of water with one atom of ammonia for every atom of nitrogen contained in the organic base. The corresponding replacement of ammonia with three atoms of water is not of unfrequent occurrence in organic chemistry.

Upon the speculation that this has been the derivation of the alkaloids, it will be easy to convert them into the essential oils from which they were derived. If we halve the formula of the oil, the first of Heldt's formulæ gives

$$(C_5H_4)^n - Hx + Ox = R.$$

A certain number of atoms of hydrogen deducted from, and an equal number of atoms of oxygen added to, n times C_5H_4 constitute the resin. If, in adding nitrogen, we deduct for each atom of nitrogen three atoms of oxygen, or, which is the same thing, for each atom of ammonia (NH_3) added, deduct three atoms of water, we have an organic body containing C, H, N and O, a body corresponding in constitution with an alkaloid.

By reversing this process, we may convert the alkaloid into its corresponding essential oil.

Take for example Papaverin, one of the alkaloids of opium, analyzed by Merck, $C_{40}H_{21}NO_8$.*

Three atoms of oxygen for the atom of nitrogen, united to the eight atoms of oxygen, making eleven in all, correspond with eleven atoms of hydrogen, which, added to the twenty-one present, make thirty-two.

$$C_{40}H_{21}NO_8 - N - O_8 + H_8 + O_3 = C_{40}H_{29} + O_3,$$

which correspond with

$$C_{40}H_{32} = (C_5H_4)^8.$$

There is doubt still resting upon the constitution of most of the alkaloids. Of those considered as best established, the following examples will be sufficient for a practical illustration of the above speculation.

Thebain $= C_{25}H_{14}NO_3 = C_{25}H_{20} = (C_5H_4)^5$.
Furfurin $= C_{30}H_{12}N_2O_6 = C_{30}H_{24} = (C_5H_4)^6$.
Codein $= C_{35}H_{20}NO_5 = C_{35}H_{28} = (C_5H_4)^7$.

The formula $(C_5H_4)^n - H_x + O_x + O_y = R$, is suited to the derivation of Bebeerin.

$$C_{35}H_{20}NO_6 = C_{35}H_{29} = (C_5H_4)^7 + H.$$

* Liebig's Ann., lxvi, 125; Pharm. Contr., 1848, 930.

Harmalin requires the addition of C_2H_2 to the second of Heldt's formulæ $(C_5H_4)^n - Hx + Oy = R$.

$$C_{27}H_{14}N_2O_2 = C_{27}H_{22} = (C_5H_4)^5 + C_2H_2.$$

Chinin and Cinchonin require the subtraction of C_2.

Chinin $= C_{38}H_{22}N_2O_4$* $= C_{38}H_{32} = (C_5H_4)^8 - C_2$.
Cinchonin $= C_{38}H_{22}N_2O_4$† $= C_{38}H_{32} = (C_5H_4)^8 - C_2$.

Strichnin requires the deduction of an atom of carbonic acid, or its equivalent CH_2, and the same formula of resin as that of Bebeerin.

$$C_{44}H_{24}N_2O_4 = C_{44}H_{34} = (C_5H_4)^9 - CH_2.$$

Cotarnin requires the addition of an atom of carbonic acid.

$$C_{26}H_{13}NO_6‡ = C_{26}H_{22} = (C_5H_4)^5 + CH_2.$$

The following require slight modifications.

Morphin $= C_{34}H_{19}NO_6$§ $= C_{34}H_{28} = (C_5H_4)^7 - C$.
Piperin $= C_{34}H_{19}NO_6$‖ $= C_{34}H_{28} = (C_5H_4)^7 - C$.
Veratrin $= C_{34}H_{22}NO_6 = C_{34}H_{31} = (C_5H_4)^7 - C + H_3$.

It will readily be seen that in this series the differences between the essential oil and its derivative are such as would disappear with the addition or subtraction of an atom of carbonic acid, or water in some cases, and a little more or less oxydation in others.

In those bases where the quantity of nitrogen is much larger, the third formula of Heldt would still give us the corresponding resins.

$$(C_5H_4)^n - Hx + Ox + Oy = R.$$

Take for example Caffein.

$$C_{14}H_8N_4O_4.$$

The nearest essential oil of the constitution $(C_5H_4)^n$ is $C_{15}H_{12}$.

$$C_{15}H_{12} - H_4 + O_4 + O_{14} + 4(H_3N) - 12HO = C_{15}H_8N_4O_6.$$

If we deduct from this formula an atom of carbonic acid, we have

$$C_{15}H_8N_4O_6 - CO_2 = C_{14}H_8N_4O_4.$$

Theobromin differs, as has been remarked,¶ from Caffein only by C_4H_2.

$$C_{14}H_8N_4O_4 + C_2H_2 = C_{16}H_{10}N_4O_4.$$

The construction from the class of oils, above referred to, of the formulæ of those alkaloids in which the quantity of hydrogen is much greater, is more difficult.

The foregoing relationships have an interest taken in connection with the inquiry to which attention has been directed, to wit, *May there be a common form among bodies having a common taste?*

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* Ann. Ch. Phys. [3] xix, 363; Ann. d. Ch. u. Phar., lxii, 95.
† Ann. Ch. Phys. [3] xix, 365. ‡ Ann. Ch. Phys. [3] xix, 370.
§ Ann. Ch. Phys. [3] xix, 361; Ann. d. Ch. u. Phar., lxiii, 98.
‖ Ann. Ch. Phys. [3] xix, 363.
¶ Ann. d. Ch. u. Pharm., lxi, 338 † Pharm. Cent. Blatt., 1847, 424.

Art. XXII.—*Foucault's Pendulum Experiment.*

The peculiar interest of Foucault's experiment with the Pendulum, by which the rotation of the earth is proved even within the walls of an ordinary lecture room, has obtained for it very general attention, and it has already been repeated in numerous places in this and other countries. The occurrence from which M. Foucault was led to his discovery is thus related by him.* "Having fixed on the arbor of a lathe and in the direction of the axis, a round and flexible steel rod, it was put in vibration by deflecting it from its position of equilibrium and leaving it to itself. A plane of oscillation is thus determined, which, from the persistence of the visual impressions, is clearly delineated in space. Now it was remarked that on turning around with the hand, the arbor which formed the support of this vibrating rod, the plane of oscillation was not carried with it, but always retained the same direction in space." From this came the conclusion that a pendulum set in motion will continue in the same plane of vibration, however the point of suspension be rotated—a fact easily proved by a simple trial with a weight at the end of a cord. The rotation of the point of suspension may make the pendulum revolve on its axis; but the plane of vibration will remain the same. The reason for this is obvious: the swinging pendulum, when about to return (after an outward swing) from its point of rest, is made to move from that point by gravity alone, and can therefore fall but *in one direction;* and the momentum acquired by falling carries it beyond this centre in the *same* direction to the point of rest on the other side; here again it is in a like condition, and must return under the force of gravity in one and the same line, gravity acting in the same direction whether the point of suspension be rotated or not. Thus the plane of vibration is fixed from the very nature of the forces at work.

It is evident, therefore, that if a pendulum were swinging at the pole of the earth, the plane of vibration, as it would not change with the revolution of the earth, should mark this revolution by seeming to revolve in the contrary direction, and in 24 hours it would make *apparently* the whole circuit of 360 degrees. But at the equator, the plane of vibration is carried forward by the revolution of the earth, and so undergoes no change with reference to the meridians. Between the equator and poles, the time required for the pendulum to make 360° varies according to the latitude, being greater the farther from the pole. For these intermediate latitudes the problem is beautifully solved on a globe.

Having a globe for the trial, select, for instance, latitude 30°, and apply the principle that the plane of vibration is constant

* Bibl. Universelle, March, 1851.

notwithstanding the revolution. Suppose the plane of vibration to be the meridian of Greenwich: draw a series of lines across the parallel of 30°, parallel to this meridian; each of these lines will show precisely the position of the pendulum, in the revolution, at the point where the line intersects the parallel of latitude. If, for example, we draw one of these parallel lines across the intersection of 30° with the *first* meridian circle east of Greenwich; another across the intersection of the parallel of 30° with the *second* meridian; another across the *third*, and so on;—each will mark the position of the plane of vibration after a revolution of as many degrees as are included between the meridians. Continuing this on, the parallel lines become more and more easterly, and finally they are exactly east and west in longitude 180°; or in other words, the plane of vibration, which is still parallel to the Greenwich meridian, is actually at right angles to the meridian of 180°; this plane has therefore changed apparently 90°, while the earth was revolving 180° or making half its circuit. And if this be continued, it will be found that the parallel lines will make the whole circuit of 360° in twice the earth's revolution, or what is equivalent, in 48 hours.

These parallel lines drawn on the globe, it is to be observed, should be parts of great circles, and are strictly parallel to one another only at the intersections with the parallel of latitude, like the meridians where they cross the equator; their tangents at these intersections will be actually parallel throughout, like the tangents to the meridians at the equator, and these tangents represent the true angle of the plane of vibration.

Again take latitude 70°, and in the same manner draw lines parallel to the meridian of Greenwich, going eastward. These parallel lines will rapidly diverge from the meridian, the divergence being nearly 9½ degrees for every 10 degrees of longitude; in lon. 95° 46½′ E. the intersecting line will point east and west, having made 90° in its apparent revolution. In 191° 33′ it will have made 180°, and in 383° 6′, (or 23° 6′ east of the meridian of Greenwich,) it will have completed the whole 360°; so that in latitude 70° the time of the apparent revolution of the plane of vibration, is a little over 25½ hours. The globe thus exhibits to the eye the actual uniform position of the plane of vibration, and at the same time its apparent revolution. By marking these parallel lines at one end with an arrow-head, and also describing an arc with the point of intersection as a centre, the increasing divergence from the meridians, and the apparent rotation by east, south, and west to north, is well shown.

If now tangents be supposed to be drawn to each meridian circle, at its intersection with any parallel of latitude, say that of 70°, these tangents will intersect at a point in the axis of the earth extended; and the angle included between any two such

tangents is the angle which the corresponding meridians make with one another in the given latitude. The plane of vibration, since it continues parallel to itself, will therefore change with reference to the meridians, just the amount of the angle included between these tangents. This is readily seen on the globe, marked off as above explained, in which the Greenwich meridian is the starting point. The angle which one of the parallel lines drawn on the globe (or its tangent) makes with the meridian it intersects is (from the nature of parallel lines) equal to the angle between the tangent to this meridian and that of Greenwich. The sum therefore of the angles between all the tangents to the meridians, will be the amount of apparent variation in the plane of vibration for 24 hours. These tangents—which are strictly the cotangents of latitude—form together the surface of a cone whose base is the parallel of latitude, and whose angle of surface at summit is equal to the revolution of the pendulum in 24 hours. If this cone be supposed to be cut open and laid out on a flat plane, it will form a sector of a circle, whose angle at the centre equals the angle around the apex of the cone. The radius of this sector (or of its circle) equals the cotangent of latitude, ($cot\ L$); and the circumference of the sector is actually a parallel of latitude—a parallel of latitude having been the base of the supposed cone. Now as the number of degrees in any arc varies with the length of the arc as related to the radius of the circle, or as $\frac{arc}{R}$; and since the *arc* here is a parallel of latitude and these parallels vary with the cosine of latitude ($cos\ L$), and since also the radius (R) equals $cot.\ L$ —it follows that the number of degrees in the arc (or the number expressing the apparent motion of the plane of vibration for 24 hours,) will vary as $\frac{cos\ L}{cot\ L}$, an expression equivalent to the *sine* of latitude.

Other demonstrations arrive at the same result, but none is more simple or more conclusive.

The theory thus involves no necessary consideration of the forces engaged, by which many explanations of the experiment are encumbered, but is simply a geometrical problem, based on the position of the meridians of a revolving sphere, and the fact that the pendulum moves in a fixed direction, parallel to the meridian in which it is started.

The idea involved in Foucault's experiment "seems to have occurred long ago, and is mentioned in a paper in the Phil. Trans. 1742, No. 468, by the Marquis de Poli, in the course of some observations on the pendulum of a different kind. He remarks, 'I then considered (adopting the hypothesis of the earth's motion,) that in one oscillation of the pendulum there would not be de-

scribed from its centre perfectly one and the same arc in the same plane'; but he does not pursue the subject as being foreign to his immediate object."* It appears also, (Comptes Rendus, 1851, No. 6,) that in 1837, Poisson had hinted at such an effect, but supposed it of insensible amount.

Different modes of varying the experiment have been proposed. The following is suggested by Poinsot. If two balls are suspended in contact, with a spring between them, and then by a sudden action of the spring are thrown apart and thus held by some attached contrivance, they will retain, after the change of position, their original rate of velocity, or that of the earth where they originally were, and consequently will commence to revolve. It would seem that if the cause mentioned be the source of motion they should not revolve if thrown apart east and west, or at right angles to a meridian. But if viewed in a different light it appears to be a fact that they would revolve in whatever direction separated. Suppose the halves of a sphere to be thus thrown apart and so retained; they have the momentum of the earth as before, but no *relative* motion, and consequently they are in the condition of the opposite points of rest of a vibrating pendulum, and will have an apparent revolution around the centre between them.

M. Baudrimont has observed that if torsion could be wholly avoided, a ball suspended or a horizontal bar would exhibit the rotation like a vibrating pendulum. But in these projects there is a fatal difficulty besides that from torsion. Such bodies, at the time when suspended, have the actual motion of objects at the place where they are, and will retain it; and consequently under no circumstances can they give results like those of the pendulum, or show any corresponding effect whatever.

In performing the pendulum experiment, the ball of the pendulum should be an accurately turned sphere or cylinder, having a place of suspension above and an elongated point below, well centered. It is best suspended by means of wire. The simplest mode to fasten it is to solder the wire into a hole drilled of the same size in a larger piece of metal, and secure this last in the ceiling or other support above. The swinging of the pendulum, by flexing the wire at the junction above, will after a while break it off. But if of steel instead of iron, the flexion will be distributed along a portion of its length, and the wire will last longer without breaking. To mark the motion, a circle (three feet or more in diameter) divided into degrees, is placed below the pendulum; the apparent motion of the plane of vibration, is observed (in north latitude) to be uniformly from left to right, or with the hands of a watch. For starting the pendulum when there is no better contrivance, it may be held, previous to letting it swing,

* Phil. Mag. [4] i. 561.

by a cord passed once around it, the hand resting at the same time on some firm object; when all oscillation has ceased, it may be let off by dropping the cord. In going the circuit, the ball of the pendulum has always the same side towards the north, and consequently it rotates on its axis with the earth.

However careful the trial, the motion of the pendulum soon appears to be somewhat elliptical. This has been attributed solely to accidental causes, and it is true that the slightest error of direction in letting off the pendulum will necessarily produce it. But on a following page, Rev. C. S. Lyman shows that a degree of ellipticity is a necessary result of the earth's rotation.

J. D. D.

ART. XXIII.—*Note on Heteronomic Isomorphism;* by JAMES D. DANA.

IN Volume Nine of this Journal* I published views on certain isomorphous groups among minerals, tracing this quality to a relation in atomic volume, a principle already admitted, but showing that this relation is most correctly exhibited when the aggregate atomic volume is divided by the number of atoms (or molecules) of the elements present. Thus for Fe O, I would divide the atomic volume, obtained in the usual way, by 2, which reduces the compound to the condition of a unit, as if consisting, as in effect it does, of $Fe^{\frac{1}{2}}\ O^{\frac{1}{2}}$. Again, for $Fe^2\ O^3$, I divided by 5, as the compound consists essentially of $Fe^{\frac{2}{5}}\ O^{\frac{3}{5}}$, the sum of the fractions making a unit. This method carried out with the feldspars, exhibited a relation between them of actual (or approximate) equality in atomic volume, and also a connection between the system of crystallization of these species and the atomic volume,—the monometric (as Leucite) having the highest number, the monoclinic the next highest, and the triclinic a lower number.

Farther study is required before all the difficulties connected with this subject, arising from isomerism and differences in the elements, are mastered. But in the comparison of compounds consisting of like elements though in different proportions, the method appears to be satisfactory, and affords conclusions of great simplicity.

These views are well elucidated by many groups of silicates, and they give increased interest to the recent results of Rammelsberg with the tourmalines. This distinguished chemist, after numerous analyses, makes out *five* chemical groups in

* P. 220, 1850.

this species, and in accounting for their similarity of crystallization, deduces as follows their atomic volumes.—(Pogg. Ann., lxxxi, 31.)

	Formulas of Tourmaline.	Mean atom. vol.
I.	$\dot{R}^3(\ddot{S}i^2, \dot{B}^3)+3\dot{R}(\ddot{S}i, \dot{B})$ - - -	1808
II.	$\dot{R}^3(\ddot{S}i^2, \dot{B}^3)+4\dot{R}(\ddot{S}i, \dot{B})$ - - -	2217
III.	$\dot{R}^3(\ddot{S}i^2, \dot{B}^3)+6\dot{R}(\ddot{S}i, \dot{B})$ - - -	3013
IV.	$\dot{R}(\ddot{S}i, \dot{B})+3\dot{R}(\ddot{S}i, \dot{B})$ - - -	1464
V.	$\dot{R}(\ddot{S}i, \dot{B})+4\dot{R}(\ddot{S}i, \dot{B})$ - - -	1850

He then observes that the numbers 1464, 1808, 1850, 2217, 3013, have the relation (correcting his 1·25, by substituting 1·26)

$$1 : 1{\cdot}24 : 1{\cdot}26 : 1{\cdot}51 : 2{\cdot}06,$$

or very closely

$$1 : 1\tfrac{1}{4} : 1\tfrac{1}{2} : 2 = 4 : 5 : 6 : 8.$$

But let us now divide these numbers by the number of atoms of the elements, and we shall find the atomic volumes, as thus deduced, very closely equal.

		No. of atoms.	Atomic vol. ÷ No. of atoms.		Atomic vol. deduced.
Formula	I.	41*	1808 ÷ 41	=	44·1
"	II.	50	2217 ÷ 50	=	44·34
"	III.	68	3013 ÷ 68	=	44·31
"	IV.	33	1464 ÷ 33	=	44·36
"	V.	52	1850 ÷ 42	=	44·05

This equality is certainly very remarkable, and the identity of crystallization is attributed to it with good reason.

We also remark that the number of atoms 33, 41, 42, 50, 68, have to one another the ratios

$$1 : 1{\cdot}24 : 1{\cdot}27 : 1{\cdot}51 : 2{\cdot}06,$$

which are coincident, as will be observed, with the ratios obtained by Rammelsberg for the atomic volumes. *The ratios* 4 : 5 : 6 : 8, which this chemist deduces, *are in fact therefore only the ratios of the number of atoms*, 33 : 41 : 50 : 68.

Art. XXIV.—*Mineralogical Notices.* No. III.

1. *New Species.*

Gurolite, a new mineral; T. Anderson, (Phil. Mag. [4], i, 111.)—Occurs on Skye, at Storr, nine miles from Portree, in basalt; it is associated with apophyllite, stilbite and laumonite, though found in the finest specimens where these minerals do not abound. The name *gurolite* (more correctly *gyrolite*,) alludes to the spherical

* In the first formula, $\dot{R}^3$ contains 6 atoms or molecules; $\ddot{S}i^2$, 8; $3\dot{R}$, 15; $3\ddot{S}i$ 12; making in all 41.

form of its concretions, and is from γυρος, *orbiculatus*. Structure radiating, and surface of the concretions appearing striated owing to the plates of which it is formed rising to irregular distances above the surface; cleaves easily parallel to the plates. Color white; lustre vitreous, passing into pearly on exposure; perfectly transparent in thin plates. Very tough. Hardness between 3 and 4. B.B. yields water, swells up and separates into thin pearly or silvery plates. On charcoal swells up, splitting into thin laminæ and fuses to an opake enamel. With borax, yields a transparent colorless glass; with soda fuses with difficulty to an opake mass. Readily attacked by hydrochloric acid.

Composition according to T. Anderson,

	$\ddot{S}i$	$\dot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$
	50·70	1·48	33·24	0·18	14·18=99·78
Oxygen	26·86		9·49		12·60

He thence deduces the oxygen ratio for the lime, silica and water, (considering the other ingredients as unessential,) 1 : 3 : 1½, and the formula $2\dot{C}a\ddot{S}i+3\dot{H}$. The formula requires a little less lime and more silica and water, which discrepancy Mr. Anderson attributes to partial efflorescence. The ratio of lime and silica is the same as in Edelforsite. Its efflorescence and crystallization in plates distinguish it from dysclasite.

Arœoxene, a new vanadate of Lead and Zinc.—Kobell received this new mineral through Prof. Döbner. It was found at Dahn in the Palatinate, with galena, and had been considered a chromate of lead. It occurs massive but imperfectly crystalline, with some traces of a columnar structure. Color red, darker than crocoisite, with a brownish tinge; streak pale yellowish. H.=3. B.B. on coal fuses easily with intumescence, and yields an arsenical odor with a globule of lead, the latter being larger with soda. With borax fuses in the reduction flame to a bright green glass, which in the oxydation flame becomes gradually light olive green, then clear yellow, and on cooling changes to a pale greenish tint. Heated with concentrated muriatic acid, the powder easily decomposes, and the liquid is first yellow, then brownish, and after giving out chlorine, emerald green. On adding spirits of wine, heating it, and pouring off from the solution the separated chlorid of lead, it is still green; but on concentrating it by means of a vapor bath and then diluting it with water it takes a fine sky-blue color. In this characteristic, it is like other allied vanadium compounds. Von Kobell found in the mineral 48·7 p. c. of oxyd of lead and 16·32 of oxyd of zinc. The vanadium lead ore analyzed by Damour contained only 6·34 p. c. of oxyd of zinc. —(J. f. pr. Chem., l, 496.)

Enargite, a new ore of Copper; A. Breithaupt, (Poggend. Ann., lxxx, 383.)—Enargite comes from Morococha, district of

Jauli, in the Cordilleras of Peru, at a height of 14,000 feet (French), and also from a mine near Freiberg, along with other copper ores. It occurs in Peru abundantly in large masses containing occasional small druzes of crystals, imbedded with tennantite in crystalline limestone. The Freiberg mine affords it in acicular crystals, which are distinguished from other glances by the prismatic cleavage. Lustre metallic, slightly imperfect; color iron-black; streak black; H. = 3 or that of calc spar; G. = 4·43–4·445; easily pulverized. Crystallization trimetric; the crystals presenting the planes of a rhombic and rectangular prism; rhombic prism (∞P) = 98° 11′: cleavage prismatic, perfect; brachydiagonal and macrodiagonal distinct; basal indistinct; octahedral (P) in traces. Fracture uneven. B.B. in a glass tube, decrepitates and gives with little heat a sublimate of sulphur; in a stronger heat, fuses and produces sulphuret of arsenic of a reddish yellow color; on charcoal it gives out arsenous acid, oxyd of antimony and oxyd of zinc; and in the reduction flame, it finally yields with borax a globule of copper. Analysis of the Peruvian ore afforded Plattner, (ibid, p. 386)—

S	As	Sb	Cu	Fe	Zn	Ag
32·222	17·599	1·613	47·205	0·565	0·228	0·017=99·449

This gives the ratio for the sulphur,—the arsenic and antimony,—and the copper, iron and zinc, 1605 : 197 : 1214, or very nearly 8 : 1 : 6, whence he deduces the formula (writing Cu for copper and the allied metals)—

$$[8\mathrm{Cu\,S} + \mathrm{As\,S^3}] + [2\mathrm{Cu\,S} + \mathrm{As\,S^3}],$$

or perhaps $3(\mathrm{Cu, Fe, Zn})\,\mathrm{S} + (\mathrm{As, Sb})\,\mathrm{S}^5$,

equivalent to sulphur 32·64, arsenic 19·11, copper 48·25.

Carmine Spar; F. Sandberger, (Pogg. Ann. lxxx, 391.)—Carmine spar is a red mineral occurring with cube ore (Beudantite) at Horhausen in Saxony, in quartz and brown iron ore. Crystallization not distinct, probably rhombic; occurs in clusters of fine needles and spheroidal forms of a columnar structure; cleavage parallel to the faces of a rhombic prism. Lustre vitreous, but pearly on a cleavage face; color carmine to tile-red; powder reddish-yellow; translucent; brittle; hardness 2·5, or between rock salt and calc spar. B.B. on charcoal fuses easily to a steel gray globule, giving out arsenical vapors. With soda, yields a globule of lead, and with borax the reaction of iron is obtained. In a glass tube over a spirit lamp, does not change. Heated in concentrated muriatic acid it dissolves very easily to a gold-yellow fluid, in which chlorid of gold does not deposit metallic gold; soluble in nitric acid. From these and other trials, it is inferred that the mineral is an anhydrous arsenate of oxyd of lead and iron; the quantitative relations have not been determined.

Dechenite, a vanadate of Lead; Dr. C. BERGEMANN, (Pogg. Ann. lxxx, 393.)—Dechenite comes from the Lauter valley in Rhenish Bavaria, near Nieder-Schlettenbach, where the rock is the "bunter sandstein." It occurs in small botryoidal masses, having a crystalline texture, and presenting when purest a dull red color. There appear to be indications of a rhombohedral cleavage. In these masses there are occasional wart-shaped grains of a more yellow color. The streak is always yellowish. Lustre of fresh fracture greasy; G.=5·81; H.=4, or that of green lead ore. B.B. alone in the platinum forceps it fuses easily to a yellowish glass; in a glass tube gives no water; on charcoal, does not decrepitate like the known vanadate ore, but fuses easily to a yellowish green pearl, which yields a slag containing some grains of lead. With more of the assay, the odor of arsenic is sometimes given off. With salt of phosphorus and borax, gives the reaction of vanadic acid. Soda yields a white enamel containing grains of lead.

According to the examinations, the mineral consists of

	$\dot{Pb}$	$\ddot{V}$		
1. Dull red variety,	47·164	52·915	=	100·079
2. " "	46·101	53·717	=	99·818
3. Yellowish "	49·27	50·57	=	99·84

The first two analyses afford the oxygen ratio for the base and acids 1 : 3, equivalent to the formula $\dot{Pb}\,\ddot{V}$ = vanadic acid 45·33, lead 54·67.

Octahedral oxyd of Antimony.—M. H. DE SENARMONT describes (Ann. Ch. Phys. [3], xxxi, 504,) an oxyd of antimony of octahedral forms from Sensa, near the sources of Aïn-el-Bebbouch, (Province of Constantine.) At one locality, the oxyd is in masses often cavernous, composed of capillary filaments parallel or a little divergent, and pearly or adamantine in lustre; it is the prismatic species. But at another mine called *Mimine*, the same oxyd exists in saccharoid masses, granular or compact, having cavities covered with octahedral crystals that are sometimes more than a centimetre in diameter. Several admitted of measurement and proved to be the regular octahedron, the cleavage octahedral, but a little difficult. The composition is that of the pure oxyd, or oxygen 15·68, antimony 84·32. G.=5·22–5·3, while that of the prismatic oxyd is 5·56. Hardness less than that of calcite. Colorless; transparent; strongly refracting without regular action on polarized light. Specific gravity of the massive variety 5·23, and color mostly grayish; contains sometimes less than 1 per cent. of lead, and there may be 1 to 3 per cent. of gray clay. It is probable, from the existence of thermal waters in the soil below, that these crystals were formed in the humid way. Oxyd of antimony is then *dimorphous*. Arsenous acid presents

the same forms. Wöhler* observed prismatic crystals which were recognized as like those of oxyd of antimony by Mitscherlich; while octahedral crystals are readily obtained by sublimation or by solution. [*Senarmontite* is an appropriate name for this octahedral oxyd.]

Mineral species described by Prof. C. U. Shepard, (Proc. Amer. Assoc., 4th Meeting at New Haven, p. 311.)—1. *Dysyntribite.* Occurs in considerable masses in St. Lawrence county, New York, and has some resemblance in appearance to serpentine. It is found at Rossie, and at Natural Bridge in Diana, and is usually in connection with the specular iron of the region. It is massive, granular, tough, almost dull, with an even splintery fracture; color dark green, grayish or yellowish, sometimes mottled with red and black. H. = 3·5–4. G. = 2·76–2·81. B.B. in thin fragments fuses to a white porcelainous mass. In an open tube yields water. Contains according to Prof. Shepard—

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{H}$	$\dot{C}a, \dot{M}g$
	47·68	41·50	5·48	4·83	*trace* = 99·49
Oxygen	24·77	19·39	1·21	4·29	

whence he deduces the formula $16\dot{A}l\,\ddot{S}i + \dot{F}e^3\,\ddot{S}i^4 + 9\dot{H}$.

[The dysyntribite is somewhat remarkable for its external resemblance to serpentine, while at the same time it is aluminous in composition. The specimens are very various in appearance, and look much more like a rock than a mineral species, (as might be inferred from the improbable formula given,) appearing to be a result, to some extent, of metamorphic action.]

2. *Rutherfordite*, (ibid, p. 312.)—Occurs in crystals and grains at the gold mines of Rutherford Co., North Carolina, along with rutile, brookite, zircon and monazite. Monoclinic; M : M = 93°. Cleavage, none. Fracture conchoidal; lustre of fracture shining and resinous; color yellowish brown; opake. H. = 6·5; G. = 5·58–5·69. B.B. in a glass tube cracks, glows as if on fire, emits much moisture and turns yellow; alone infusible; with borax forms slowly a clear yellow glass.

According to trials by Prof. Shepard, it is supposed to contain titanic acid, oxyd of cerium and possibly oxyd of uranium and yttria.

3. *Paracolumbite*, (ibid, p. 313.)—Occurs a mile southwest of Taunton, Mass., in minute quantities in a boulder of granite containing a peculiar greenish-white feldspar. Massive, in grains and short irregular seams; iron-black, sometimes with a tinge of purple, and a black streak; imperfectly metallic; opake. H. about 5. From his examinations, Prof. Shepard infers that the mineral seems to be composed of the oxyds of iron and uranium in combination with a metallic acid, which is not the titanic.

* Wöhler on the dimorphism of arsenous acid, Pogg. Ann., xxvi, 177.

4. *Houghite*, (ibid, p. 314.)—Occurs near Oxbow, St. Lawrence Co., N. Y., and also in Rossie, associated with spinel, from which region specimens were received by Prof. Shepard from Dr. Franklin B. Hough of Somerville. It presents oblong flattened reniform concretions, rarely above $\frac{3}{4}$ths of an inch long, with botryoidal surfaces, whitish externally and bluish or reddish white within; lustre faintly pearly, glimmering. Sometimes has a spinel crystal as a nucleus. H.=2·5. G.=2·02–2·03. It decrepitates and emits water before the blowpipe, losing 33$\frac{1}{3}$ p. c. by ignition. Appears to be a hydrate of alumina and magnesia.

[Houghite has been studied recently by Mr. S. W. Johnson, of the Yale Analytical Laboratory, who finds that it is a pseudomorph, often of spinel and probably also at times of scapolite; some of his specimens are spinel crystals (octahedral) in one part, and true Houghite in another, and all conditions of change are well illustrated by them. Mr. Johnson is still engaged in his investigations on the subject.]

5. *Marasmolite*, (ibid, p. 315.)—From the feldspar quarry near Middletown, Ct., along with columbite, pitchblende and albite. Monometric, with cubic cleavage; color brownish black, and streak reddish brown; brittle; H.=3·5; G.=3·73–3·74. Composition, according to Prof. Shepard:—

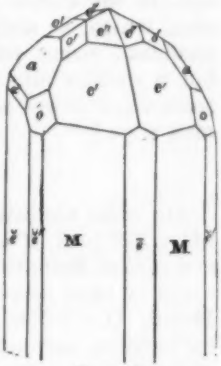
Sulphur 38·65	Zinc 49·19	Iron 12·16

affording the ratio 5 : 3 : 1, and the formula $3ZnS + FeS^2$. The name is from *μαρασμος*, *decaying*.—[The marasmolite, according to the writer's examinations of Prof. Shepard's specimen, is a brittle, partially decomposed blende, containing free sulphur in minute points throughout it, as seen with a glass. This free sulphur accounts for the excess in the analysis; allowing thus for a small excess, the composition will become 3Zn S+Fe S, which is the formula of the marmatite variety of blende.]

6. *Calyptolite*, (ibid, p. 316.)—From Haddam, with chrysoberyl, garnet and beryl; also from the feldspar quarry near Middletown. Crystals minute, and usually square prisms with pyramidal terminations; surfaces not smooth and often somewhat concave; color dark brown; lustre adamantine; opake. H.=6·5. G.=4·34. B.B. in an open tube, yields moisture, having an acid reaction, and becomes pale yellowish white; alone, whitens but does not fuse; does not fuse readily with soda; with borax dissolves slowly into a glass which is yellow while hot, but colorless on cooling. When heated in powder with sulphuric acid for some time, it appears to be completely decomposed, and the glass tube exhibits corrosion. "The quantity of the mineral was too small for a satisfactory examination; but the absence of silica, lime, magnesia and alumina was ascertained; and the probability that the substance is a fluo-columbate of some of the less com-

mon earths and oxyds, established." [We may mention that the most common form closely resembles that of garnet, and the mineral had been referred to this species, which it externally resembles. The angle of the pyramid is given at 122° to 124°; but the surfaces are so irregular that the measurements are uncertain.]

7. *Eumanite*, (ibid, p. 317).—From Chesterfield, Mass., at the albite locality. Only a single minute crystal less than a grain in weight is known. Form trimetric; M : M = 123°. M : e′ = 136°; e′ : e′ = 151° 30′; e′ : e″ = 159° 30′; ĕ : *a* = 127° 40′; M : ĕ = 118°—118° 30′; e′ : *a* = 127° 30′; *a* : *o* = 144° 20′; ĕ : *o* = 128° 20′; e′ : *o* = 156° 30′; surface M rather imperfect and not very lustrous; the other faces brilliant. Color blackish-brown, resembling certain crystals of tin ore. Translucent; color by transmitted light deep red, like almandine garnet. H. above 6.



Eumanite.

[The crystal of eumanite has closely the form of topaz, even to the general character and position of the planes on the summit, and is near figure 393 in Dufrenoy's Mineralogy; the angles also are nearly identical. Topaz gives M : M = 124° 19′; and if M on ĕ in eumanite is 118°, it will give 124° for M : M in eumanite—M, M, it should be noted, are the least lustrous faces of the crystal; M : e′ = 135° 59′ (136° in eumanite.) The mineral must therefore be closely isomorphous with topaz, if not identical with it, and some other characters are needed to show that the latter supposition is not true, although so peculiar in its color. In the figure, the edge *o*′ : e″ on the right is parallel to the edge e″ : e″, but not so that on the left; we cannot say which is right.]

8. *Corundophilite*, (ibid, p. 318).—Occurs with corundum near Asheville in Buncombe county, N. Carolina, in imperfectly stellate groups, and also spreading out in laminæ between layers of corundum. A single crystal, exceedingly minute and less than $\frac{1}{25}$th of a grain in weight, was monoclinic and gave the angles M : M about 120°; P : M = 97° 30′ and 82° 30′; P(0*P*) : $\infty P' \infty$ = 88° to 89°; P(0*P*) : $mP' \infty$ = 122° 30′. Cleavage basal, perfect; also in traces parallel with M and the shorter diagonal of P. Lustre of cleavage faces commonly pearly. Color dark leek-green, passing into gray and greenish black; streak like the color. Thin laminæ flexible, but less so than talc. B.B. affords a little moisture in a glass tube; alone instantly turns black, and without phosphorescence. Melts at the extremity to a shining black globule; with borax, forms readily with effervescence a clear bottle green

glass. On analysis it afforded Prof. Shepard, Silica 34·75, protoxyd of iron 31·25, alumina 8·55, water 5·47, making a loss of nearly 20 p. c., a portion of which he attributes to the alkalies. 0·146 gramme was used in the analysis. Neither lime nor magnesia were detected. The name is from Corundum and φιλος, *friend.*

[This mineral, as observed by the writer, is usually thin foliated or micaceous. It closely resembles chloritoid in appearance, which, as stated by J. Lawrence Smith, who analyzed a specimen, occurs frequently with the Corundum of Asia Minor; but it divides into much thinner laminæ than is usual in that species and is less brittle. The angles are nearly those of common mica.]

2. *Described Species.*

On some Canadian Minerals, by T. S. Hunt, (Phil. Mag., [4], i, 322.) 1. *Perthite*, of Thomson.—This feldspathic mineral is from Bathurst, and forms part of a eurite rock, being sometimes in large cleavable masses. Form apparently monoclinic. H.=6. G.=2·576–2·579; a darker colored fragment 2·583. Lustre vitreous, inclining to pearly; color a light flesh red, in alternating bands, with reddish or pinchbeck brown, the bands half a line or a line wide, coincident with one of the planes T; the darker bands on the cleavage surface T give a golden reflexion when viewed perpendicularly, like aventurine feldspar. Analysis by Mr. Hunt.

$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$	$\dot{N}a$		
66·44	18·35	1·00	0·67	0·24	6·37	5·56	ign.	·40=99·03
66·50	19·25		0·56	0·24	6·18	5·56	"	·44=98·73

The composition is that of orthoclase, to which species, as he observes, the mineral had been referred by Shepard, Dana and himself.

2. *Peristerite*, Thomson.—The specimens furnished Mr. Hunt by Dr. Wilson, as duplicates of those sent to Dr. Thomson, were a feldspar containing disseminated quartz grains; and others from the locality were fine cleavable masses often free from the quartz. Form triclinic, near albite in cleavage, being perfect parallel to P and M, less distinct with T, a fine play of colors on P, as in labradorite, a delicate cerulean blue prevailing which occasionally passes into light green and yellow. H.=6. G.=2·625–2·627. Composition according to Mr. Hunt:—

	$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{N}a$	$\dot{K}$	$\dot{C}a$	$\dot{M}g$		
I.	66·80	21·80	0·30	7·00	0·58	2·52	0·20	ign.	0·60=99·80
II.	67·25					2·03		"	0·66

whence the mineral is *albite.*

3. *Bytownite.*—The specimen analyzed was from Dr. Holmes and was taken from a specimen pronounced by Dr. Thomson to

be this mineral. H. about 6·5. G.=2·732–2·733. Massive, granular, strongly coherent; grains with one perfect cleavage and indications of another oblique to it. Lustre vitreous, approaching to pearly upon the cleavage faces; translucent; color greenish white. The smoky blue mineral from Perth generally circulated among mineralogists as bytownite, is a mixture apparently of the true bytownite with what appears to be a black hornblende. Composition of the bytownite according to Mr. Hunt,

$\ddot{S}i$	$\ddot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{F}e$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
47·40	30·45	14·24	0·87	0·80	2·82	0·38	2·00=98·96
47·30							1·80

Mr. Hunt deduces from these results and the characteristics of the species, that it is anorthite. [The oxygen ratio for the protoxyds, peroxyds and silica is 1 : 2·66 : 4·62, which is wide from 1 : 3 : 4, the ratio for anorthite; and therefore, it must be, if this species, an impure variety of it. The mineral thiorsauite of Genth, has nearly the same composition according to Genth's analysis; but this Iceland feldspar is considered impure anorthite by Rammelsberg.]

4. *Labradorite.*—Common in boulders from Labrador to Canada West, but has not been observed in place. A specimen from Drummond, C. W., of a lavender blue color and pearl-gray opalescence, had the sp. gr. 2·697, and consisted as follows:—

$\ddot{S}i$	$\ddot{A}l$	$\dot{C}a$	$\dot{F}e$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
54·70	29·80	11·42	0·36	*trace*	2·44	0·33	0·40=99·35

Mr. Hunt observes with regard to the water in this and other feldspars, that he agrees with Delesse and Laurent, in considering it as belonging to the constitution of the mineral and not hygroscopic.

5. *Raphilite* of Thomson.—This mineral from Lanarck, C. W., is tremolite. H.=5·5. G. (in powder) =2·845. Lustre vitreous silky; color grayish or greenish-white, becoming reddish on weathered surfaces. Composition:—

	$\ddot{S}i$	$\ddot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	$\dot{N}a$	$\dot{K}$	
	55·30	0·40	13·36	22·50	6·30	*traces*	0·80	0·25	ign. 0·30=90·31
Oxygen	28·72	0·19	3·80	8·72	1·40		0·21	0·04	

6. *Retinalite and Serpentine.*—The retinalite of Thomson was founded on a serpentine from near Grenville, sent him by Dr. Holmes, and a portion of the same specimen he gave Mr. Hunt for analysis; other specimens were procured at the locality. It fills seams or penetrates granular limestone near a trap dyke. H.=3·5. G.=2·494–2·525–2·476. Lustre resinous; streak white; color honey yellow passing into oil green and olive green; translucent; fracture conchoidal. Composition:—

	$\ddot{S}i$	$\dot{F}e$	$\dot{M}g$	$\dot{N}a$	$\dot{H}$
I.	39·34	1·80	43·02	*trace*	15·09=99·25
II.	40·10	1·90	41·65	0·90	15·00=99·55

Another serpentine of similar character, from Grand Calumet Island, having a pale wax color and sp. gr. 2·362–2·381, afforded—

$\ddot{S}i$	$\dot{F}e$	$\dot{M}g$	$\dot{H}$
41·20	0·80	43·52	15·40 = 100·92

Mr. Hunt observes that the mineral has the composition of marmolite of Hermann, but is not foliated; and he inclines to consider the species as not distinct from serpentine.

7. *Zircon.*—Crystals half an inch thick and an inch or more long occur at Grenville, along with tabular spar, calc spar, sphene, pyroxene and plumbago. G. = 4·602–4·625. Color brownish red, passing into flesh-red and cherry-red. Analysis afforded Mr. Hunt:

Silica 33·7 Zirconia 67·3 = 101·0

The zirconia contained a trace of iron which was not separated.

Celestine.—The crystallization of celestine has been studied with much labor by M. Hugard, and some new crystalline forms are described by him (Ann. des Mines, [4], xviii, 3.) Mr. Hugard adopts as the mean of his measurements, for M : M, 104°, the angle varying between 103° 30′ and 104° 30′; he observes that the crystals which vary most from this are chemically impure. A neat crystal from Lake Erie gave him constantly less than 104° (mean, 103° 30′); but the Lake Erie celestine contains a considerable proportion of sulphate of barytes. The paper is illustrated by twenty-seven figures.

Limestone of Predazzo.—This mineral, called Predazzite by Petzholdt, is a carbonate of lime and magnesia containing water. This chemist deduced the formula $2\dot{C}a\ddot{C} + \dot{M}g\ddot{C}\dot{H}$. J. Roth, by his analysis (J. f. pr. Chem. lii, 346,) makes the composition of a white variety, $2\dot{C}a\ddot{C} + \dot{M}g\dot{H}$ = carbonic acid 34·11, lime 43·41, magnesia 15·50, water 6·98 = 100. He obtained—

	$\ddot{C}$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$		
I.	33·35	44·67	14·54	6·96	$\ddot{S}i$, $\dot{A}l$, $\dot{F}e$ 0·48	= 100·00; G = 1·868
II.	33·98	42·63	14·05	7·00	$\ddot{S}i$ 0·29 $\dot{A}l$, $\dot{F}e$ 0·49 =	98·44; G = 1·018

For another variety of a gray color he obtained, excluding the alumina, silica and oxyd of iron, which amount to 6 per cent.—

	$\ddot{C}$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$	
I.	29·23	35·70	24·78	10·92 =	100·63; G = 1·005
II.	28·10	35·97	24·47	10·97 =	97·51; G = 0·621

Whence he has the formula $\dot{C}a\ddot{C} + \dot{M}g\dot{H}$ = carbonic acid, 27·85, lime 35·44, magnesia 25·32, water 11·39 = 100. Brucite occurs in the marble of Predazzo, and also a variety of serpentine.

Composition of Apatite from Snarum; G. Rose (Monatsb. Akad. zu Berlin, March, 1851, 173.)—Analyses by M. Weber in the laboratory of H. Rose:—

	$\dot{C}a$	$\dot{F}e$, $\dot{C}e$, $\dot{Y}$	$\ddot{P}$	Cl
I.	53·16	1·76	41·82	2·66
II.	53·79	1·74	41·47	"
III.	53·44	1·86	41·33	"
Mean,	53·46	1·79	41·54	2·66

Calculating the lime phosphate from the amount of phosphoric acid, the chlorid of calcium from the chlorine, and the fluorid from the remaining lime, G. Rose deduces for the composition—

$\dot{Ca}^3\ddot{P}$	Ca Cl	Ca F	$\dot{Fe}\dot{Ce}\dot{Y}$
90·66	4·17	3·07	1·79

In the analysis formerly made by G. Rose, this chemist found in the Snarum apatite, lime 54·75 and chlorine 2·713, whence he deduced—

$\dot{Ca}^3\ddot{P}$	Ca Cl	Ca Fl
91·13	4·28	4·59

agreeing very nearly with the analysis by Weber. Weber's results with the new modes of determination of phosphoric acid therefore confirm the earlier deductions of Rose.

Diaspore.—Occurs according to Prof. C. U. Shepard, (loc. cit. p. 319,) at the fluor spar and topaz vein at Trumbull, Conn., in thin or 6-sided tables, flattened parallel to the shorter diagonal. It is the species formerly announced by Prof. Shepard as euclase. M : M = 130° 30′, M : o = 125°; o : o = 152° 30′; o : on $\alpha\breve{P}\infty$ = 104° 30′. H. = 7–7·5. G. = 3·29. Analysis afforded Prof. Shepard, Alumina 84·9, water 15·1 = 100.

Hydrargillite from Brazil.—Von Kobell announces this mineral (J. f. pr. Chem. l, 493, 1850,) as occurring in Brazil, and as having been mistaken for wavellite. It occurs in spheroidal concretions, having a radiato-lamellar structure, giving some indications of rectangular prisms. Color grayish to yellowish-white; translucent; lustre pearly inclining to vitreous; hardness between calc spar and fluor spar. Dissolves wholly in concentrated sulphuric acid. Composition according to von Kobell:—alumina with a trace of silica 67·26, water 32·39 = 99·65, and giving the formula $\dot{Al}\dot{H}^3$. It was found to contain no phosphoric acid.

New form of Compound Crystal of Quartz.—M. G. Rose has described a compound crystal of quartz (Monatsb. Akad. zu Berlin, March, 1851, p. 171), which consisted of four crystals, one a central, and each of the others united to the first correspondingly by a primary rhombohedral face, the axes of the central and the others, making an angle equal to the complement of double the angle between a rhombohedral plane in the primary and its vertical axis; the latter angle is 38° 13′ according to Kupffer, whence the inclination of the axes is 103° 34′. The primary faces of the pyramid are larger than those alternate, and the prism has its alternate planes larger so as to approach a 3-sided form. The specimen is from the serpentine of Reichenstein, and is associated with small crystals of arsenical iron.

Serpentine.—G. Rose has examined crystals of serpentine in the collections of Berlin (Monatsb. Berl. Akad.,) and sustains the

view that they are pseudomorphs of olivine. There are three crystals which have an interior of olivine. A portion of a crystal from Snarum, received from Quenstedt, afforded Hefter in his laboratory,—

	$\dot{S}i$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	$\dot{H}$	
	41·93	53·18	2·02	0·25	4·00 = 101·38 − ;	G = 3·0384
Oxygen	21·79	20·58	0·46	0·06	3·58	

Showing that it is a mixture of olivine and serpentine. The crystals of Snarum and of the Fassa valley in the Tyrol are therefore pseudomorphs. The villarsite of Dufrénoy, which is similar in its crystalline forms, he refers to the same origin. He regards serpentine as an amorphous material incapable of crystallization. Substances perhaps occur imperfectly crystallized, having the same composition; but the only substance of this nature, which he recognizes, is chrysotile. Schiller spar, which is allied in composition, the author regards as no natural mineral in crystallization, but a pseudomorph after augite, with which it is often associated. He alludes to the frequent occurrence of serpentine pseudomorphs imitative of many of the mineral species, as hornblende, augite, garnet, chondrodite, spinel, mica, &c.

Serpentine of the Vosges.—The serpentine of the Vosges and its associated minerals, have been investigated chemically and otherwise by M. Delesse (Ann. d. Mines, [4], xviii, 309), whose descriptions are very full and complete. The minerals noticed are garnet, chromic and magnetic iron, iron pyrites, diallage, chlorite, chrysotile, calcite, dolomite, nemalite, brucite, feldspar, quartz, talc, asbestus, and specular iron.

Garnet occurs of red, brownish and greenish or grayish-green colors. B.B. it fuses with difficulty, and in a tube yields some water. H. = 6·5. G. = 3·150. Composition:—

$\ddot{S}i$	$\ddot{A}l$	$\ddot{C}r$	$\ddot{F}e$	$\ddot{M}n$	$\dot{M}g$	$\dot{C}a$	
41·56	19·84	0·35	10·17	*trace*	22	4·25,	ign. 1·58 = 99·75

Diallage is sometimes disseminated through the serpentine, but occurs commonly in small masses or in the intersecting veins. Color deep olive-green, and occasionally, emerald green. The latter variety is sometimes found within a nodule of garnet. Lustre a little pearly but not like bronze. G = 3·154. Analysis gave—

$\ddot{S}i$	$\ddot{C}r, \ddot{M}n$	$\dot{F}e$	$\dot{M}g$ (by diff.)	$\dot{C}a$	
56·33	1·50	6·73	31·93	1·40,	ign. 2·11 = 100

The 2·11 p. c. given off by heating are nearly all water. Formula $\dot{R}^3\ddot{S}i$.

Chlorite occurs in veins or in nodules of garnet, and evidently the garnet has been altered to chlorite, as the different stages of the process may be detected. B.B. becomes grayish and takes a metallic lustre, and if in lamellæ the edges are rounded, forming

a grayish green glass. With salt of phosphorus gives evidence of chrome, and with soda, a manganese reaction. Composition of the chlorite of the Col de Pertuis—

$\dot{S}i$	$\dot{A}l$	$\dot{C}r$	$\dot{F}e$	$\dot{M}n$, $\dot{M}g$ (by diff.)	$\dot{C}a$
33·23	14·78	1·49	6·28	1·39 30·76	1·86, ign. 10·21 = 100

Bischof has shown that a solution of bicarbonate of magnesia will transform, even when cold, silicate of lime recently prepared into carbonate of lime and silicate of magnesia; and with this fact, M. Delesse observes that the change of garnet into chlorite may be explained. The pseudomorphosis has taken place over a wide extent.

Chrysotile occurs in seams having a delicate fibrous texture; it is translucent, and the fibres separated are transparent; color oil-green, usually clear, sometimes olive-green; lustre silky. G. = 2·223. B.B. yields water; on platinum wire, it gives a bright light and fuses with difficulty to a glass slightly brownish. Dissolves with borax or soda. Composition:—

$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}g$ (by diff.)	$\dot{H}$
41·58	0·42	1·69	42·61	13·70 = 100

The picrolite of Stromeyer has the same composition.

Nemalite occurs at Xettes in the Vosges, and also at Saint Sabine. *Brucite* is found at Goujot.

The *Serpentine* is of various qualities and colors. Analyses:

	$\dot{S}i$	$\dot{A}l$	$\dot{C}r$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$ (by diff.)	ign.
1. Blackish-green, Liésey,	40·83	0·92	0·68	7·39	*trace*	1·50	37·98	10·70=100
2. Maroon-red, Goujot,	42·26	1·51	—	7·11	—	0·80	38·90	9·42=100

Specific gravity of the first 2·749.

In the second analysis, the alumina as obtained included some chrome and oxyd of manganese. The serpentine of Goujot takes a fine polish and sells at 54 francs the square meter.

The author next discusses the relative age and the origin of the minerals and serpentine, giving many views of interest. He observes that of the minerals which have been formed in serpentine, those most magnetic (as those rich in iron) have remained in the paste, while those that are diamagnetic have been separated into fissures, so as to form veins or amygdaloids. The magnetic and diamagnetic forces, according to this view, have acted an important part in the development and distribution of the included minerals.

Picrolite of Silesia.—Analysis by Dr. List, (Ann. d. Ch. u. Pharm., lxxiv, 241):—

$\dot{S}i$	$\dot{M}g$	$\dot{F}e$	$\dot{H}$
44·606	39·748	2·631	2·576 = 99·561

Leuchtenbergite.—Breithaupt (Pogg. Ann., lxxx, 577) observes that the specimens of Leuchtenbergite are evidently more or less altered by exposure or otherwise, and this is farther proved by the fact that Komonen obtained but 8·62 per cent. of water,

and Hermann 12·5 per cent. He therefore suggests that quite probably the mineral may exist in the unaltered state and prove to be a distinct species.

Delessite of Naumann, is a ferruginous chlorite from amygdaloid.

Ozarkite.—On an examination of this mineral, Prof. Shepard obtained the following result (Proc. Assoc., loc. cit., p. 322.)—$\ddot{S}i$ 40·91, $\dot{A}l$ 15·75, phos. lime 4·17, lime 4·52, water 15·10, and observes that this removes the mineral from Scolecite, to which it is referred by Mr. J. D. Whitney. [The investigations of the species by Messrs. Brush, Whitney and Shepard, the latter in two different trials, are so widely different, that we have not reason to believe that in any case a *simple* mineral has been examined.]

Soda-mesotype of the Zircon-syenite of Laurvig.—Analysis by C. G. Gmelin (Pogg. Ann., lxxxi, 311):—

$\ddot{S}i$	$\dot{A}l$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
48·680	26·369	16·002	20·362	9·550 = 100·958 ;	G. = 2·207

Hence the formula $\dot{N}a\ddot{S}i + \dot{A}l\ddot{S}i + 2\dot{H}$. It gelatinizes with muriatic acid, before and after heating. The feldspar of the rock contains much soda.

Hydrosilicates of Alumina.—The following are analyses by M. Salvetat:—I. of Halloysite from Saint Jean de Colle, near Thiviers (Dordogne,)—II. Halloysite of unknown locality,—III. of Smectite from Condé, near Houdan (Seine-et-Oise,)—IV. Lenzinite from La Vilate, near Chanteloube, (Ann. Ch. Phys. [3], xxxi, 102.)

	$\ddot{S}i$	$\ddot{S}i$ gel.	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$	$\dot{N}a$	$\dot{H}$	
I. *H.* from St. J. de C.	45·55	1·04	22·60	1·05	1·66	0·30	0·04	0·06	26·20,	q'tz 1·04 = 99·46
Oxygen	23·60		10·55	0·32	0·46	0·12	0·01	0·01	23·28	
II. *H.*, loc.?	45·44	—	24·00	1·35	0·83	0·09	0·93		26·70 = 99·35	
Oxygen	23·60		11·21	0·41					23·93	
III. *Smectite*	43·00	1·50	32·50	$\dot{F}e$ 1·20	1·02	0·30	0·40		21·70 = 101·62	
Oxygen	22·34		15·18						19·08	
IV. *Lenzinite*	36·36	0·20	36·00	$\dot{F}e$ 1·95	—	0·18	0·50		21·50,	q'tz 1·64 = 100·13
Oxygen	18·89		16·82	0·61					19·02	

Formulas, omitting the protoxyds which are probably impurities,

I. and II. $\dot{R}\ddot{S}i^2 + 7\dot{H}$ III. $\dot{A}l^2\ddot{S}i^3 + 7\frac{1}{2}\dot{H}$ IV. $\dot{A}l\ddot{S}i + 3\dot{H}$.

The Halloysite from near Thiviers is tender, soapy and mild to the touch, of paler rose color than that of Montmorillon. B.B. infusible, and at a red heat loses color. Does not form a paste with water. In contact with water it divides into small fragments, and gives out bubbles of air with an argillaceous odor. Boiling sulphuric acid attacks the mineral. The second Halloysite has similar characters. On account of the difficulty of distinguishing between hygroscopic water and that of combination,

the author acknowledges that some doubt exists with regard to this term in the formula. Dried at 100° C. in a moist air, the 7Ḣ (obtained after drying at 16° C.) are reduced to 4Ḣ; and at 100° C. in a dry air, to 3Ḣ.

The Smectite is greenish, not homogeneous in appearance, and affords a magma of two substances, one colorless and the other slightly greenish, but both of the same composition; and the mass encloses here and there crystals of gypsum. In a certain state of humidity it appears transparent and almost gelatinous. It adheres strongly to the tongue. Moistened with water it yields an argillaceous odor and acts like Halloysite, except that it makes a plastic paste. It contains 7½Ḣ, when dried at 16° C., 5½, if dried at 100° in a moist atmosphere, and 4½ at 100° in a dry atmosphere.

The Lenzinite occurs in pegmatite (whence it is explored for pottery) in small thin beds, having a brownish color, soft enough to be impressed with the fingers, but not plastic. On drying, the color slightly changes. B.B. infusible. Partly dissolved in hot sulphuric acid, leaving a white insoluble residue. At 100° C., the mineral contains 2½Ḣ.

Atheriastite.—J. F. L. Hausmann shows (Pogg. Ann., lxxxi, 567,) that this mineral which was formerly referred to Scapolite, but recently instituted as a species by Weibye, is an altered scapolite, as is suggested by the writer in this Journal, vol. x, p. 246.

Feldspar of Laurvig and Friederichsvärn.—Analysis by C. G. Gmelin, (Pogg. Ann., lxxxi, 313,)—

	S̈i	Ẍl	K̇	Ṅa	C̈a	Ḟe		
1. Laurvig,	65·90	19·46	6·55	6·14	0·28	0·44, ign.	0·12=	98·89; G.=2·5872
2. Friederichsvärn,	65·19	19·99	7·03	7·08	0·48	0·63, "	0·38=	100·78; G.=2·590

The first is of a pale greenish gray color, the second sky-blue.

Epidote.—The objections which Rammelsberg brought against the investigations of Hermann on the constitution of Epidote, are replied to by Hermann in the Jour. f. pr. Chem., vol. liv, p. 250. Hermann had in a former memoir presented the conclusion that the species included several distinct chemical compounds. Rammelsberg, in reply, after a new determination of the proportion of protoxyd and peroxyd of iron, referred all the varieties which he examined under a single formula, and suggested that the others would conform to it. Hermann in his recent memoir offers reasons in favor of his former deductions.

Gadolinite, (Phil. Mag. [4], i, 350.)—Occurs in Ireland near Galway in a trap rock containing also epidote.

New American localities, reported by Prof. C. U. Shepard.—(loc. cit., p. 320.) 1. *Ores of Uranium at Middletown, Ct.* Pitchblende occurs at the feldspar or "china-stone" quarry in small crystals which are octahedrons with truncated edges and

angles. It is associated with uranochre and also traces of carbonate of uranium and the sulphate (Johannite).

2. *Ores of Bismuth at Haddam, Ct.*—Bismuthine was noticed by Prof. Shepard some time since as occurring sparingly at the Chrysoberyl locality of Haddam. Bismutite and Bismuth ochre are now reported by him (loc. cit., p. 320) as occurring at the same place, the former in thin coatings upon crystals of Bismuthine and the latter in a pulverulent form and usually yellow.

3. *Samarskite in Rutherford Co., N. C.*—In angular grains, some weighing a quarter of an ounce, from the washings of one or more gold mines. The form appears from some of the fragments to be near that of Columbite. Color velvet black; streak dark reddish-brown. Opake; H. = 5·5; G. = 5·69. When first heated in a glass tube, it decrepitates, flies to pieces, glows slightly after the manner of Gadolinite, but remains of a black color. [No analysis or chemical examination is given.]

4. *Thorite at Danbury, Ct.*—This mineral is from Danbury, where it occurs with the Danburite, sphene and augite. It is stated to be either thorite or a new species. It occurs in minute square prisms ($\frac{1}{2}\frac{1}{0}$th inch long) with truncated edges and having a pyramid at summit. The lower part of the four pyramidal planes forms a separate set of planes inclined at an angle of 160° to the terminal set; but in the specimen, only one out of the four of the lower set is present and this is not very distinct. Angle of the terminal set (P), over summit, 98°; same on M ($\infty P\infty$) 120°. Cleavage imperfect. Lustre resinous; color black. H. = 5 - 6. Heated in an open tube yields much moisture having an alkaline reaction. B B. becomes brownish-red but does not fuse, but when most heated has finally a semi-fused aspect. With borax gives a glass colored by iron. [The characters given are insufficient to prove that the mineral is Thorite, as Prof. Shepard observes. The angle 98° is near the same in rutile, zircon, xenotime; calculating from this angle, the angle given as 120° would be 117° 40′. If 120° is right, 98° should be 90°, and the form might be cubic.]

Chromic iron of Baltimore.—Analysis by A. Rivot, (Ann. Ch. Phys., Oct., 1850, [3] xxx, 202.)

Fe	Al	Cr	Ca	Si, Ti?	
30·04	1·96	63·37	2·02	2·21	= 99·60

The oxygen of the peroxyd of iron and alumina is together nearly half of that of the oxyd of chrome.

Misy from Rammelsberg near Goslar.—Dr. List describes this iron sulphate as follows, (Ann. Chem. u. Pharm., lxxiv, 239.) It occurs as an aggregate of small crystalline scales having a pearly lustre approaching vitreous, a dull sulphur-yellow color. These scales, under a lens, are seen to be rhombic tables with

the acute lateral edge truncated. It does not properly dissolve in pure water, but after a while is decomposed, the fluid becoming brownish red and having an acid reaction; in water with a little sulphuric acid it is not decomposed. Analysis gave,—

$\ddot{S}$	$\dot{F}e$	$\dot{Z}n$	$\dot{M}g$	$\dot{K}$	$\dot{H}$
42·922	30·066	2·491	2·812	0·318	21·391=100.

In another trial Dr. List obtained 43·208 $\ddot{S}$ and 30·365 $\dot{F}e$. The zinc, magnesia and potash are attributable to mixture with some sulphate of zinc, of magnesia, and of potash present as impurity. Excluding these, the result becomes—

	$\ddot{S}$	$\dot{F}e$	$\dot{H}$
	47·075	40·622	12·313
Oxygen	28·203	12·170	10·947

whence the ratio, nearly, 2·5 : 1 : 1, and the formula $\dot{F}e^3\ddot{S}^5+6\dot{H}$, which is that of Copiapite (H. Rose) excepting the water which is $18\dot{H}$ in that species.

Manganese Ores of the Pyrenees.—For a paper on the position and origin of these ores by M. Gruner, see Ann. des Mines, [4,] xviii, 61. The author also discusses the origin of associated minerals and ores.

Glaucodot.—This mineral according to Breithaupt, (Pogg. Ann., lxxxi, 578,) occurs at Orawitza in the Bannat along with a pale yellow calc spar. It is thin columnar. M. Patera obtained, Sulphur 19·78, arsenic 43·63, cobalt 32·02, iron 4·56.

Copper Nickel of Ayer.—Analysis by Ebelmen, (Ann. des Mines, [4,] xi, 55.)

As	Sb	S	Ni	Co	Fe		
54·05	0·05	2·18	43·50	0·30	0·45	Gangue 0·20	= 100·75

White Blende of New Jersey, (Phil. Mag. [4], i, 23.)—The colorless Blende from Franklin, New Jersey, called "Cleiophane" by Mr. Nuttall, has been analyzed by T. H. Henry, with the following result:—Zinc 67·46, sulphur 32·22 = 99·68, corresponding to a very pure blende. Sp. gr. at 60°, 4·063. A trace of cadmium was found by means of Wollaston's test.

Troostite of New Jersey, (Proc. Amer. Assoc. at New Haven, 4th meeting, p. 146.)—An analysis of Troostite by Henry Wurtz, afforded

$\ddot{S}i$	$\dot{Z}n$	$\dot{M}n$	$\dot{F}e$	$\dot{M}g$	$\dot{C}a$
27·91	59·93	3·73	5·35	1·66	1·60 = 100·18,

giving the oxygen ratio for the protoxyds and silica 14·96 : 14·50, or very closely the formula $\dot{Z}n^3\ddot{S}i$.

Calamine and Electric Calamine.—A paper on the analysis of these ores by Emil Schmidt is to be found in the Jour. f. pr. Chem., li, 257.

Wulfenite or Molybdate of lead from the mine Azulaques, near Blanca in Zacatecas.—Analysis afforded Dr. C. Bergemann,

(Pogg. Ann., lxxx, 400,) $\dot{M}o$ 37·65, $\dot{P}b$ 62·35 = 100·00. The crystals are of a light yellow color.

Mimetene of the Mine Azulaques in Zacatecas.—Dr. C. Bergemann obtained in an analysis (Pogg., lxxx, 401,)

$\dot{P}b$	$\ddot{A}s$	Cl
74·961	23·065	2·445 = 100·471,

giving the formula $Pb\,Cl + 3\dot{P}b^3\,\ddot{A}s$. This corresponds to Arsenic acid 23·065, oxyd of lead 66·948, chlorine 2·445, lead 7·140.

Gray Copper from the foot of the ridge Mouzaïa in Algiers.—Analysis by Ebelmen (Ann. des Mines, [4,] xi, 47):—

S	Sb	As	Cu	Fe	Zn
27·25	14·77	9·12	41·57	4·66	2·24 = 99·61.

Specific gravity 4·749; occurs in highly modified dodecahedral crystals.

Dioptase.—Dioptase (Smaragdo-chalcite) is announced by F. Sandberger (Pogg. Ann., lxxxii, 133,) as occurring in a sandstone containing Spirifers in the Duchy of Nassau, betwen Oberlahnstein and Braubach.

Sulphate and carbonate of Copper at Bristol, Ct.; Prof. C. U. Shepard, (Proc. Amer. Assoc., New Haven, p. 322.)—A dull verdigris green mineral containing carbonic acid occurs upon the vitreous copper ore of Bristol. Prof. Shepard observes that if when more fully examined it proves to be a definite chemical compound, as he now suspects, it will then be proper to bestow upon it a mineralogical name. J. D. D.

(To be continued.)

Art. XXV.—*Notice of the Report on the Geology and Topography of a portion of the Lake Superior Land District;** by J. W. Foster and J. D. Whitney.

The district embraced within the Report of Messrs. Foster and Whitney covers an area of 16,000 square miles, and nearly the whole of it is still an unbroken wilderness. The opening of the Michigan Copper mines has given it a peculiar economical interest, and, more than this, it has a high geological importance, hardly exceeded elsewhere, on account of the singular character of the mineral region, the structure and relations of the rocks in different parts, and the display of the phenomena of drift. The investigations in the same region, made by Dr. C. T. Jackson,

* Report on the Geology and Topography of a portion of the Lake Superior Land District, in the State of Michigan; by J. W. Foster and J. D. Whitney, United States Geologists. In two parts. Part I, Copper Lands. 244 pp. 8vo, with 12 plates and several maps. Washington, 1850. 31st Congress, 1st Session. Ex. Doc. No. 69.

have been noticed at length in this Journal. Messrs. Foster and Whitney, in the volume just published, present the first part of their Report on the region. The work, although mainly devoted to those points in the geology of the district bearing on the mines, and including much of practical detail on mining, presents a clear and systematic view of its general structure as far as examined, and conclusions of important geological bearing. A second part is promised, which shall contain further details of a more purely scientific character, with an account of the fossils, by Mr. James Hall, who accompanied the party in the explorations of one season. The authors acknowledge the aid of Messrs. S. W. Hill and E. Desor, as first assistants, Mr. Wm. Schlatter as draftsman, and Mr. W. D. Whitney as botanist. Mr. Desor's attention was particularly directed to the drift, and the results of his observations add much to the interest of the survey. On some geological points, the authors conflict with the conclusions of Dr. Jackson; and it remains for future investigation to clear up all the doubt that may remain upon the disputed questions.

We propose to run through with the work, giving a brief review of some of the results arrived at, and principally by citation from the volume.

The Introduction presents a historical view of the explorations in the Copper region. After touching upon the accounts of the Indians, and of the Canadian and other explorers, and also the Journey of Mr. H. R. Schoolcraft in 1819, 1820, and mentioning that the conclusion arrived at by exploration thus far, had been that the copper deposits to be found would be too inaccessible to be profitably worked—the authors allude to the investigations of Dr. Douglass Houghton, State Geologist of Michigan, and observe that "in his annual report, presented to the legislature of Michigan, February 1, 1841, the great features of the country were sketched with a masterly hand, and the first definite information with regard to the occurrence of the deposites of native copper in the rocks was laid before the world." This geologist had just planned a system for a thorough survey of the whole region, and had entered upon the prosecution of it, when, in the midst of his labors, he suddenly died by drowning, in October, 1847. Since this period, the region has been explored by Dr. C. T. Jackson, as already stated, and by the authors of the present report.

The Lake Superior Land district is bounded on the north by Lake Superior, east by St. Mary's river, south by Lakes Huron and Michigan, and west by the Montreal and Menomonee rivers, being situated between 45° and 49° north latitude and 83° 45′ and 90° 33′ west longitude. A striking feature in the topography of the region is the parallelism of the northwest shore of Lake Superior, the south shore, west of Keweenaw Point, and the

narrow island of Isle Royal between, proving, as the authors state, that this part of the lake must be the course of a great synclinal valley, arising from two parallel axes of elevation on opposite sides of the lake. We might add farther, that this course is *at right angles* to the great range of lakes that extends from Erie and Michigan northwest to the Northern ocean, which range is parallel to the Rocky Mountains and the Northwest coast of America on one side, and to Hudson's Bay and the shores of Davis Straits on the other.*

We cite with regard to the mountains, from pages 34, 35.

"1. Two granite belts occur in the Northwest—one forming the axis between the waters of Lake Superior and Hudson's Bay; the other between Lake Superior on the north and Lake Michigan and the Mississippi river on the south. The outline of the Canada range is N. 60° E., though subject to minor irregularities. It forms the rim of the Canada shore for more than two-thirds of its extent. The summits of this range are generally rounded, and rarely elevated 1,500 feet above the lake.

On the southern shore, a belt of granite approaches the lake near Dead river, and thence stretches westward, sinking down into a somewhat broken plain southwest of Keweenaw bay. Its widest expansion is about thirty miles. This belt constitutes the Huron mountains, which in places attain an elevation of 1,200 feet above the lake. They do not range in continuous chains, but exist in groups, radiating from a common centre, presenting a series of knobs, rising one above another, until the summit-level is attained. Their outline is rounded or waving—their slope gradual. The scenery is tame and uninteresting. Hemmed in by these knobs, it is not unusual to find numerous lakes and meadows covered with grass, forming an agreeable feature in the landscape. These meadows appear at one time to have been lakes, which have been filled with the detritus brought down from the surrounding hills, or drained in consequence of the water having worn down the barriers which existed at their outlets. Towards the western extremity of the district, the granite reappears in low ridges, and crosses the Montreal within twelve miles of its mouth. There are subordinate patches of granite in other portions of the district, attaining no great elevation, which will be described in the detailed report.

The metamorphic belt folded around the granite is traversed by numerous detached ridges of hornblende and feldspar rocks, ranging in E. and W. direction, and rarely rising more than 200 feet above the surrounding country, and present a more rugged aspect than the granite. A quartz range starts from the lake

* Origin of the Grand Outline Features of the Earth, by J. D. Dana, this Journal, [2,] iii, 382 and 389.

shore at the mouth of Carp river, and extends westwardly beyond Teal lake. Its outlines are sharp and well defined, its escarpments bold, with fragments of rock strewn along its base. The boundaries of this group are defined in the accompanying maps.

2. A trap range starts from the head of Keweenaw Point and runs west twenty miles; then, curving to the southwest, crosses Portage lake near its head, and the Ontonagon river twelve miles from its mouth, and is thence prolonged into Wisconsin. Its length is more than one hundred and fifty miles; its width, from one to twelve. Between Iron and Presqu'-Isle rivers, a spur shoots off in the form of a crescent, constituting the Porcupine mountains. Another spur branches off from the main chain on the south, and is prolonged nearly parallel with it for twenty miles. This belt is made up of parallel ranges, presenting step-like or scalar declivities on the side opposite the lake, while the other consists of gradual slopes. Mount Houghton, near the head of Keweenaw Point, rises up like a dome, to the height of eight hundred and eighty-four feet; the Bohemian mountain, near Lac la Belle, is little inferior in height. The valley of Eagle river, on the northwest, is bounded by abrupt, overhanging cliffs, some of which rise to a height of five hundred feet above the surrounding country.

In the vicinity of the forks of the Ontonagon, the cliffs are equally bold, and from their summits the eye has an almost unlimited range. To the west, the trap range is distinctly marked for many miles, and the west branch of that stream flows along its base. The highest and most imposing cliffs are north and east of Agogebic lake. Farther west, the ranges are less precipitous and more irregular, much of the country traversed by these rocks consisting of rolling table-lands.

The highest elevation attained by the Porcupine mountains is one thousand three hundred and eighty feet. A remarkable gorge occurs in township 51, ranges 42 and 43. This gorge lies about two miles south of the lake, and in that distance the ground rises about a thousand feet. Suddenly the traveller finds himself on the brink of a precipice five hundred feet deep, at the base of which lies a small lake, so sheltered and hemmed in by the surrounding mountains that the winds rarely ruffle its surface. Gloomy evergreens skirt its shores, whose long and pendent branches are so faithfully reflected on the surface that the eye can with difficulty determine where the water ends and the shore begins. From this lake flows the Carp river, and the beholder occasionally catches a glimpse of its waters as they wind through a narrow valley towards the great reservoir. To the west, and extending for five miles, he sees a perpendicular wall three hundred feet in height—occasionally broken through by a transverse gorge—at the base of which are numerous fragments, which

have tumbled from the cliffs above. Still further down is to be seen the rich foliage of the maple intermingled with the dark green of the fir and cedar, and still beyond succeeds a level plain, stretching out for twenty miles, and clothed with a dense growth of trees; while in the distance the Black river hills are seen, blue and indistinct, resting like a cloud upon the horizon.

That portion of the district occupied by the detrital rocks rarely rises three hundred feet above the lake. It is not unusual to see ridges of sand and clay forming considerable elevations. The Grand Sable is a remarkable accumulation of this character, rising to the height of three hundred and forty-five feet. Point Iroquois, at the outlet of the lake, is three hundred and fifty feet in height, and composed wholly of transported materials."

There is much information in the Report on the meteorology of the region, and changes of level in the lakes, which for the present we pass by. Under the head of the Geology of the Copper Region, the trappean and other igneous rocks come first under consideration, 1. the ranges of Keweenaw Point; 2. those between Portage Lake and the Montreal river, in which district the Porcupine mountains constitute the highest points; and 3. those of Isle Royale. In these districts, the rocks are compact trap, amygdaloid, porphyritic trap, trap-breccia, epidote trap, and compact quartz or jasper.* Epidote is an abundant mineral. It frequently accompanies the amygdaloid, and often fills the cavities with radiated crystallizations. It also replaces the hornblende of the trap, forming the epidote trap which is very various in character; the seams of quartz and calc spar containing copper are almost always accompanied by this mineral. On the United States location, the trap and epidote are seen in alternating bands, the cavities of the former being filled with epidote and quartz, and those of the latter with quartz and calc spar. The Jaspery rock forms the highest points of the Porcupine mountains. It is usually of a deep brick red color, sometimes banded like ribbon-jasper, and contains seams of quartz. A quartzose porphyry has a brick-red color and contains small crystals of white feldspar, not generally exceeding an eighth of an inch in length. "Almost invariably, fine rounded particles of vitreous quartz are found distributed through the Jaspery base. It forms an eruptive mass, and often includes fragments of the pre-existing igneous and sedimentary rocks."

Besides these there is a singular rock of a feldspathic base, of a light reddish color, through which irregular crystals of red feldspar and small rounded particles of quartz are discoverable, intermixed with a greenish mineral which appears to be epidote.

The Porcupine mountains afford some copper, but there are not indications enough to warrant mining enterprises.

* See also the Report of Dr. C. T. Jackson, pages 659 to 662.

Isle Royale is the counterpart of Keweenaw Point; but although the Jesuits formed the most extravagant notions of its mineral wealth, nothing has lately been revealed to justify those expectations; at least, it is vastly inferior to Keweenaw Point or the vicinity of the Ontonagon as a mining region. Moreover the soil is scanty and the timber dwarfed and stunted.

"The shores are lined with dense but dwarfed forests of cedar and spruce, with their branches interlocking and wreathed with long and drooping festoons of moss. While the tops of the trees flourish luxuriantly, the lower branches die off and stand out as so many spikes, to oppose the progress of the explorer. So dense is the interwoven mass of foliage that the noonday sunlight hardly penetrates it. The air is stifled; and at every step the explorer starts up swarms of musquitoes, which, the very instant he pauses, assail him. Bad as this region is by nature, man has rendered it still worse. Fires have swept over large tracts, consuming the leaves and twigs and destroying the growth, while the heavy winds have prostrated the half-charred trunks, and piled them up so as to form almost impenetrable barriers.

As we ascend the ridges, the maple and birch replace the cedar and the spruce, and the physical obstructions become less formidable. These ridges occur at short intervals, and preserve a great degree of parallelism—bearing northwest and southeast; they are uniformly precipitous on the north, and gently sloping on the south. The valleys between are occupied by swamps, clothed with a dense growth of resinous trees, or with small lakes arranged in chains. The coast of the island is rock bound, and, like Iceland, intersected by numerous *fiords*, or narrow and deeply indented bays."

Trappean rocks form numerous ridges, seldom reaching 500 feet in height and running from N.E. to S.W. They are at times in regular columns; and also pass into amygdaloid and varioloid trap. In numerous places they form distinctly *a series of beds* which are conformable with the detrital rocks. The intercalations of sandstone and trap* are well seen at Chippewa Harbor, there being no less than five in less than a mile.

"These beds bear S.W. and N.E., and dip from 12° to 20° to the S.E., and respectively vary from a foot to eighty feet in thickness. When traced across the harbor a few rods only in extent, they are found to have been subjected to a powerful dislocation, extending in a N.W. and S.E. course, and amounting to 971 feet in a linear direction.

At and near the junctions of these different rocks, marked changes in their lithological characters are observed, which throw much light on their origin.

* Many facts of this nature are mentioned in Dr. Jackson's Report, page 472.

The *upper* portions of the sheets of trap are highly vesicular, resembling pumice. Fragments of amygdaloid, sometimes rounded, at others angular, are found enclosed in the pumice-like trap, as though they had become detached and afterwards reunited to the mass, while in a molten state. Numerous short and irregular fissures, extending to no great depth, are observed on the upper surface of the trap, in which sandstone has been deposited. * * * Between the *sandstone above* and the *trap below*, it is extremely difficult to determine where the one begins and the other ends. Fragments of amygdaloid, angular or partly rounded, are included in the sandstone—more numerous near the base than at the top of the deposits. Where the sandstone is imposed *on* the trap, there is little evidence of its having been metamorphosed; but, on the other hand, where the trap rests *on* the sandstone, the line of junction is clear and well defined. The trap is less vesicular; and the upper portion of the sandstone belt, for the distance of three or four feet, is converted into a ribbon jasper, having a compact texture. These phenomena have been observed at numerous places both on Isle Royale and Keweenaw Point. The beds of sandstone are not shattered, nor does the igneous rock penetrate in the form of dikes or ramifying veins. All the phenomena indicate that the igneous rocks were not protruded in the form of dikes between the strata, but that they flowed like lava sheets over the pre-existing surface; and that the sand was deposited in the fissures and depressions of the igneous belt, in some cases, while the mass was in an incandescent state."

Similar alternations occur in the cliffs of the shores, consisting of different igneous rocks.

"At another point on the coast the following section was observed:

	Feet.	Inches.
Compact trap, breaking into cuboidal blocks,	15	0
Porphyritic trap, - - - - -	0	3
Compact trap, - - - - -	4	0
Porphyritic trap, - - - - -	0	2
Compact trap, - - - - -	1	6
Porphyritic trap, - - - - -	1	0
Compact trap, - - - - -	1	6
	23	5

These alternations exhibited well defined lines of junction, and preserved their parallelism along the face of the cliff, as far as exposed. The bearing and dip were the same as in the section before described. The lines of division pursued an undeviating course through the several bands.

A small vein was observed at one point cutting vertically through these bands, and the veinstone exhibited marked changes in its passage through the different belts.

At a point about half a mile to the west, numerous alternations of compact trap and amygdaloid were observed, having the same regularity in bedding and inclination.

We have observed this banded structure in the igneous rocks, at short intervals, from Blake's Point nearly to Washington Harbor, a distance of forty-five miles; and throughout the entire extent of the island they present a remarkable uniformity in bearing and inclination. They were, undoubtedly, deposited at first in horizontal sheets, and owe their present inclination to the same upheaval which uplifted the associated sedimentary rocks. We regard them as purely igneous products, and not as the result of metamorphism."

In the chapter on the stratified and sedimentary rocks, other examples of the alternations of the trappean and detrital beds are given. But before mentioning the facts, the characters of the sedimentary or stratified rocks should be stated. These are comprised under three divisions; 1, *Conglomerate*, not strictly a sedimentary rock, but a volcanic tuff; 2, the *Inferior sandstone*, an equivalent, according to the authors, of the Potsdam sandstone; 3, *Compact or lower magnesian limestone*, referred to the age of the calciferous sandstone, chazy limestone, bird's eye and Black river limestones of the New York geologists. The fragments of trappean rocks in the conglomerate are often 18 inches in diameter; they have a rough surface as if fresh broken, and are not properly worn.

"The conglomerate appears to have been formed too rapidly to suppose that the masses were detached and rounded by the action of waves and currents, and deposited with silt and sand on the floor of the ancient ocean; for, while the contemporaneous sandstone remote from the line of volcanic foci does not exceed three hundred or four hundred feet in thickness, the united thickness of the conglomerate bands in the vicinity of the trappean range on Keweenaw Point exceeds five thousand feet. As we recede for a few miles from the line of the volcanic fissure, these amygdaloid pebbles disappear, and are replaced by arenaceous and argillaceous particles. We are, therefore, disposed to adopt the theory, as to the origin of such masses, first suggested by von Buch:* 'When basaltic islands and trachytic rocks rise on fissures, friction of the elevated rock against the walls of the fissures causes the elevated rock to be enclosed by conglomerates composed of its own matter. The granules composing the sandstones of many formations have been separated rather by friction against the erupted volcanic rock than destroyed by the erosive force of a neighboring sea. The existence of these friction conglomerates, which are met with in enormous masses in both hemispheres,

* Geognost. Briefe, p. 75–82.

testifies the intensity of the force with which the erupted rocks have been propelled from the interior through the earth's crust. The detritus has suddenly been taken up by the waters, which have then deposited it in the strata which it still covers.'

The junction between the trap and conglomerate is well displayed in the vicinity of Copper Harbor. The rocks bear nearly due west, with a northerly dip of 35°. The trap on the upper surface resembles pumice, the vesicles frequently empty, but oftener filled with calc spar, agates, chlorite, &c. Other portions are wrinkled, as though arrested while flowing. The lower portion of the conglomerate does not exhibit a clear and well-defined line of demarcation, but encloses angular masses of amygdaloid, as though the materials had been thrown down while the trap was in a viscid state. This appearance was particularly noticed a few hundred yards above Porter's island, where the pebbles, for the distance of twenty feet perpendicular, are enclosed in a scoriaceous mass."

On Keweenaw Point, the conglomerate rises to a height of 650 feet, and expands to a thickness of 4000 feet. The culminating points in the range are back of Horseshoe harbor and Grand Marais. At the base of the Porcupine mountains, the conglomerate and associated sandstone have a great thickness and there are numerous intercalations with trap. Near Montreal river it is 2000 feet thick and the boulders are sometimes fully three feet in diameter; the rock consists mostly of porphyritic trappean rocks and hornblende cemented by a calcareous paste.

The conditions or circumstances attending the formation of these beds of trap and their alternations with fragmentary deposits are thus explained by the authors.

"We may suppose that at one time all of this district formed a part of the bed of the primeval ocean. Adopting the theory of a cooling globe, we may further suppose that the waters were in a heated condition, and differed essentially in chemical composition from those of the present oceans. The earth's crust was intersected by numerous, powerful fissures, and the communication between the exterior and interior was unobstructed. Volcanic phenomena were much more frequent, and exerted on a grander scale. Each volcanic paroxysm would give rise to powerful currents and agitations of the water, and their abrading action in detaching portions of the pre-existing rocks, and depositing them in beds and layers on the floor of the ocean, would operate with greater intensity than at the present time. We can trace the remains of one volcanic fissure extending from the head of Keweenaw Point, in a southwesterly direction, to the western limits of the district; and of another, in a parallel direction, from the head of Neepigon bay to the western limits of

Isle Royale. Along the lines of these fissures existed numerous volcanic vents, like those observed at this day in Peru, Guatemala, and Java, which were characterized by periods of activity and repose. From these vents were poured forth numerous sheets of trap, which flowed over the sands and clays then in the progress of accumulation. During the throes and convulsions of the mass, portions of rock would become detached, and rounded simply by the effects of attrition, and jets of melted matter be projected as volcanic bombs through the air or water, which, on cooling, would assume spheroidal forms; while other portions of the rock, in a state of minute mechanical division, would be ejected in the form of ashes and sand, which, mingling with the water, would be deposited, as the oscillations subsided, among the sands and pebbles at the bottom of the sea. During the whole of this period of volcanic activity, the sands which now form the base of the Silurian system were in the progress of accumulation, and became mingled with these igneous products. The level of the sea, as evidenced by the ripple-marks, was subject to repeated alterations: sometimes it rose so shoal that the marks of the rippling waves were impressed on the sands; at others, it sank to unfathomable depths.

In the process of consolidation, the rocks became traversed by numerous fissures, and the water, charged with lime, was forced in like jets of steam, filling them with materials different from the enclosing mass. In this way the pores in the conglomerate and the vesicles of the amygdaloid were filled.

Thus alternating bands of igneous and aqueous rocks were formed, until finally the great crystalline masses of greenstone were protruded through the fissures, not in a liquid, but in a plastic state, lifting up the bedded trap and conglomerate, and causing them to dip at high angles from the axis of elevation. As the volcanic action diminished in energy, the detrital rocks enclosed fewer igneous products; and, when it ceased altogether, sand and clay, derived from regions remote from the lines of disturbance, were the only materials which, for a time, were deposited on the floor of the ocean.

To illustrate the nature of volcanic action, we need only to revert to instances which have happened within the present century. So recently as 1831, a mass of rock rose up from the sea near the coast of Sicily, where soundings had previously been made to the depth of six hundred feet. This mass, which was subsequently known as Graham's island, rose gradually from the water, until it attained an elevation of two hundred feet above the surface, and a circumference of three miles. It slowly diminished to the circumference of three hundred yards, and in the course of three months sank eleven feet below the water, leaving a dangerous reef.

The formation of this island was attended with earthquakes and water-spouts, and the effusion of vast quantities of steam and vapor. The surrounding water was covered with scoriæ and the bodies of fishes. Fragments of rock were detached by the waves and currents, and deposited in the bottom of the sea.

Now, if its bed were laid bare, it would probably be found to exhibit a section somewhat like the following:

1. A mass of volcanic rock, forming an axis or cone, crystalline or granular in proportion to the rapidity or slowness with which it parted with its heat, and the degree of pressure to which it had been subjected.

2. Volcanic breccia, consisting of fragments which had become detached and afterwards reunited with the fluid mass.

3. Coarse conglomerate, composed for the most part of pebbles derived from the upheaved mass.

4. Beds of arenaceous and calcareous particles, brought down by the rivers of the adjacent coast, and enveloping the remains of fishes, if not too perishable in their nature, and of shells, inhabiting the surrounding sea.

The conglomerates and trap tuffs would rapidly thin out as we receded from the volcanic focus, and be replaced by the silts and sediments derived from the rivers flowing into the sea.

Such, we conceive, was the process by which the rocks embraced in this report were formed. The heated condition of the fluids, as well as the gaseous exhalations constantly escaping through the open fissures, would prevent the development of animal and vegetable life.

When the igneous action became dormant, the water, having parted with a portion of its heat, would absorb carbonic acid from the atmosphere, which, uniting with the lime held in solution, would be precipitated in beds and layers at the bottom of the sea. This Humboldt conjectures to have been the origin of the vast deposits forming the Silurian limestones. As the condition of the water changed, the numerous types of animal life sprang into being, whose remains are so profusely scattered throughout the strata of that era."

There can be no doubt, judging from the known effects of igneous action, that the authors are correct in representing the conglomerate as a result attendant upon the igneous ejections. The action of the waters of the ocean on a lava stream was exhibited on a grand scale at the eruption of Kilauea, (Hawaii) in 1840, where the fused rock on reaching the sea, as Mr. Coan states, "was shivered like melted glass into millions of particles, which were thrown up in clouds that darkened the sky and fell like a storm of hail over the surrounding country," and as a result three conical elevations were thrown up in a few days, the smallest 150,

and the largest 250 feet in height. The same effects would take place in the depths of an ocean, only far more vast, when the opened fissures lie their whole length exposed to the waters; and the results would vary according to the condition or progress of the eruption, the currents that were in action at the time, and the character of the region around. Adding also the friction of the eruptive rock against the walls of the opened fissures, as suggested by von Buch, and we have a sufficient cause for the formation of the fragmentary beds.

That there were actual volcanoes in the Lake Superior region, may be doubted; for the same results as are there observed might take place by eruptions through fissures without the existence of a permanent vent and cone. In fact, nearly all (if not all) the ejections about modern volcanoes are through fissures in the slopes of the mountain and in the surrounding country. Farther evidence is needed on this point.

The *sandstone* of the region contains beds of the conglomerate and its layers alternate in many cases with the beds of trap, proving that all belong to one epoch. The rock varies in color from different dark brown shades to reddish or red; and also passes into a slate.

The *compact or lower magnesian* limestone contains fossils, which are shown by Mr. James Hall to correspond in age with the lower of the New York series. A conspicuous fossil is a Maclurea like a species from the Chazy limestone. The Leptænæ have the characters of *L. sericea*, which in its highest range does not extend above the Clinton group of New York. The species of *Orthis*, though too obscure to be identified, have the characters known only in those of the lower Silurian beds. A *Crinoid* (*Glyptocrinus*) is not more recent than the Hudson River group. The other fossils observed tend to the same conclusion.

The age of the conglomerate associated with the trap is the disputed point to which we have referred in the early part of this review. The resemblance of the trap ranges and the associated sandstones of Michigan to those of Connecticut and New Jersey had led geologists to refer all to the same era; and the age of the latter being shown by the occurrence of fossils, and especially the fossil fish, described by Mr. W. C. Redfield, to be subsequent to the coal, the era of the former was thereby supposed to be settled. Dr. Jackson, after his examinations still sustains this view. Messrs. Foster and Whitney state that the magnesian limestone, whose age is evidently lower Silurian, has been found by them to *overlie* the conglomerate, and hence they place the trap and conglomerate in the lowest Silurian or as an equiva-

lent of the Potsdam sandstone. The following are their observations on this point.—p. 117.

"The sandstone, as we ascend from the lower strata to the higher, is found to be less colored by the oxyds of iron, and to take into its composition particles of lime, until finally it passes into well characterized, compact, magnesian limestone. The upper portions of the sandstone effervesce with acids, where a granular structure only is recognizable by the eye. We apply the term magnesian to this belt to define its lithological characters, although the associated organic remains would seem to indicate the presence of several of the lower Silurian groups, which cannot be recognized by lithological differences.

The whole of the northern slope of the anticlinal axis bears evident marks of having been subjected to extensive denudation; and hence over the greater portion of this region we look in vain for traces of limestone rocks. If they existed, they have been swept away; and wherever we penetrate through the thick deposit of clay and sand, we find the rock in place to be sandstone. A limited patch of limestone, however, yet remains west of L'Anse, forming the highest elevation in that direction till we reach the trap range. It is in township 51, range 35, and occupies a portion of four sections. It was first discovered by Mr. C. C. Douglass, in the summer of 1846, but nothing farther was known until the township was subdivided in 1848, when its extent and exact locality were determined.

Near the quarter-post, between sections 13 and 14, township 51, range 35, the limestone is seen in place, forming a bluff, about 50 feet above a small stream at its base. Here the strata are nearly horizontal, though large blocks have slidden down the side of the hill, and thus appear to dip towards the east. The limestone rests upon a white sandstone, which belongs to the upper part of the formation which we have described as underlying the whole of this valley.

A little to the west of the line, between sections 23 and 24, and extending for a little more than a mile, the limestone is seen in a high cliff which runs south and gradually bends to the eastward, crossing the line, in several ridges, near the southern limit of these sections, when it disappears beneath the drift materials. Ledges of rock are occasionally exposed, from 20 to 50 feet in thickness. The height of the bluff above the surrounding country is fully 200 feet; and about 600 feet above Lake Superior. The limestone is distinctly stratified, in layers from an inch to a foot in thickness, which dip, according to measurements taken along the lower edge of the precipitous portion, from 25° to 30°; and the direction of the dip is always to the eastward, varying at different points from N. 50° E. to S. 20° E.

It is of a buff color—in some places silicious, with quartzose nodules; but in others, highly magnesian, containing about 45 per cent. of carbonate of magnesia.

From the horizontality of the first described deposit, which occurs about a quarter of a mile to the north, it seems evident that the limestone overlies the sandstone, although the position of the inclined beds of the more southerly portion of the limestone is at first difficult to explain, since the surrounding country is low and level, and underlaid by sandstone in horizontal beds. It seems evident that at this point the country has been disturbed and upheaved by igneous action beneath, which has raised the strata, without any appearance of trappean rocks on the surface. This view of the case is corroborated by the fact that at no great distance from this point an elevation occurs from which the strata of sandstone dip on all sides, and although there is no igneous rock visible, yet it is evident that the sandstone has been raised in a dome-like protuberance by a mass of igneous rock pressing upon it from below. The same cause is also indicated by the irregular variation of the magnetic needle in the vicinity observed by the linear surveyors, which is unusual except when caused by the proximity of the trappean rocks.

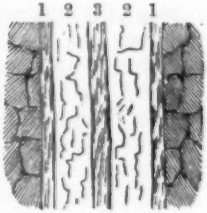
The isolated knob of trap called Silver mountain, which has been before described, is an example in point—where, however, the elevating force has not only been sufficient to raise and shatter the strata of sandstone, but, at the same time, to protrude a mass of molten igneous matter above the surface.

Geological Position.—As to the geological position of this limestone, there can be little doubt that it is superior to the sandstone. Mr. Whitney and Mr. Hill have both explored it with care, and both have arrived at the same conclusion. The sandstone, wherever observed in this region, rests unconformably on the argillaceous schists. It is seen in this position ten miles east of this deposit, and is found in the beds of the streams in this vicinity. On the southern side of the axis, Messrs. Foster and Hill found these two groups occupying the same relative position."

The point is one of great interest to American geology, and will not be permitted to rest until the facts are too clearly made out to admit of farther discussion.

In the chapters on Mines and Mining, much valuable information is condensed which will be found practically useful. The following paragraphs present some interesting facts respecting the metallic veins of the region.

"The materials composing the gangue of veins are often arranged in parallel plates, constituting what the Cornish miners call *comby* lodes. De la Beche supposes that this arrangement resulted from successive openings of the fissure.



The annexed is a section of the gangue of a vein on the southeast quarter of section 10, township 60, range 39, Isle Royale:

1. Laumonite, half an inch.

2. Prehnite, with native copper, two inches.

3. Clay, probably decomposed chlorite, one inch.

This vein appears to have been subjected to three successive openings.

The east vein of the Northwest Company exhibits two combs: that attached to the foot-wall, six inches in width, is composed of calc-spar with little copper; that attached to the hanging-wall, twelve inches in width, consists of chlorite, quartz, and calc-spar, investing copper in spangles and masses.

We have given sections of several veins in the chapter on mines, and they may be referred to in the further illustration of the structure of the veins of this region.

In the Cliff vein, there are two combs—that attached to the foot-wall containing most of the masses, while the other carries disseminated copper. The sheets of native copper, as a general thing, though not invariably, occupy the foot-wall of the vein.

Where crystals occur investing the walls, with their faces opposite, whether separated or interlocked, they afford strong presumptive evidence of the original width of the fissure.

The Prince vein, Canada shore, affords a beautiful illustration of this. The vein on Spar island is about fourteen feet in width, the walls being invested with amethystine quartz, with the faces turned outwards, occupying two feet in width, while the intermediate space is filled in for the most part with calc-spar and pyritous copper.

It is difficult to determine the order in which the materials composing the matrix of veins were deposited. In some cases the earthy substances were deposited before the metallic, and in others it is evident that copper existed in the fissures before the process of filling was complete. It is probable, however, that the copper was formed at different times.

At the Copper Falls mine, for example, we find small specks of copper enclosed in obtuse rhombohedral crystals of calc-spar, variously modified; again, we find native copper deposited *around* crystals of analcime and calc-spar, taking the form of the faces of the crystals, every line and wave being faithfully represented, as in the electrotype process. The copper often appears in arborescent forms, invested with calc-spar.

The Prince mine affords specimens of dog-tooth spar, studded with minute crystals of bi-sulphuret of copper, while the vitreous copper is often enclosed in a matrix of carbonate of lime.

The silver in this vein is found in thin leaves, between the laminæ or joints of the crystallized spar, indicating that it was deposited subsequent to the filling of the vein.

At the Minnesota mine it is not unusual to find spongiform copper adhering to the walls, which would seem to indicate that copper was the first substance deposited in the fissure. Again we find it deposited in thin plates between the joints of the crystallized quartz, which would indicate that the latter was deposited subsequent to the former. We have before us a specimen from this mine, consisting of native copper, native silver, crystallized quartz, and carbonate of lime, (calc-spar.) The copper and silver are distinct, and appear to be chemically pure. The form of the crystals of quartz is impressed on the silver and copper, and in the body of the crystals there is no trace of a metallic substance. The calc-spar, however, conforms to the silver and copper, both of these metals being disseminated through it. The silver occurs in imperfect octohedrons of the size of a pea.

This arrangement would seem to indicate the following order in the deposition of the materials: 1. Quartz; 2. Copper and silver; 3. Calc-spar.

At the Cliff and North American mines perfect crystals of copper occur only in the cavities of the matrix; when in contact with quartz, it takes the form of this substance.

The inference from these facts is, that some of the earthy materials constituting the veinstone were deposited prior to the copper and silver, while others were subsequent in their deposition.

The silver is generally found to occupy a certain position in the lode. Thus, at the Copper Falls mine, it is most abundant near the junction of the trap and conglomerate on the north; at the Cliff mine, near the junction of the crystalline greenstone and granular trap. Although silver is intimately associated with copper, yet it does not occur in sufficient quantity to justify the expense of separating the two metals. The lodes are frequently brecciated, the angular fragments evidently having been derived from the adjacent walls—and are most abundant above the points where the fissure is nearly closed."—pp. 172–174.

The authors adopt the electro-chemical theory in explaining the origin of the veins. The fact that the copper is found investing minerals, copying every wave and stria, and even incrusting zeolitic crystallizations which could not have stood the heat of fusion, favors this view of their origin.

This article has already exceeded our estimated limits and we omit therefore other citations marked off, and close with a few paragraphs on the *Cliff Mine*, pp. 127–130.

"The Cliff mine is situated on Keweenaw Point, about three miles from the lake shore, in the southwest quarter section 36, township 58 north, range 32 west. A range of elevated hills sweeps round in a crescent form, trending in a southwesterly direction, and forming the western boundary of the valley of Eagle river. In places these hills attain an elevation of 800 feet, and towards the valley present bold mural escarpments, while on the side exposed to the lake the slope is gradual. This range is composed of trappean rocks. The summit is capped by a hard crystalline greenstone, as at the Cliff mine, passing into a feldspathic porphyry, as at the Albion. Below, and forming the base of the ridge, is a belt of granular trap, occasionally amygdaloidal. Between the two, there is a thin belt of slaty chlorite about twelve feet in thickness. These belts dip to the north at an angle of 45°, conforming in this respect to the inclination of the detrital rocks which flank the range on the north. Wherever veins are observed in the greenstone, they are pinched and barren; but where they enter the compact or granular trap they expand in width, and become charged with metal. This trap has a good degree of firmness, and consists of labrador feldspar, and chlorite. It has been remarked that the best rock in this region for productive veins is neither a crystalline greenstone nor a soft porous amygdaloid, but a granular trap, with occasional amygdules scattered through it, and possessing a good degree of consistency. Where veins enter the greenstone, as before remarked, they become pinched; where they penetrate the soft amygdaloid, they become scattered and lose themselves.

The lode of the Cliff mine is seen to occupy a break or depression in the hill, and thence can be traced to its base. It was discovered in the summer of 1845, and during the succeeding fall a drift was carried into the greenstone about one hundred feet, and between that point and the summit several others were opened. When first discovered, the vein was only to be seen in the upper belt of greenstone, the metalliferous zone being concealed by detritus. No one could have inferred from its appearance at that time that the enormous masses of copper existed but a short distance below which subsequent explorations revealed. * * * * At the summit it appeared hardly more than an inch or two in width: the gangue was mostly prehnite, with copper associated with silver, incrusted with beautiful capillary crystals of red oxyd. Further down the vein was again exposed; here it had expanded to the width of nearly two feet, the veinstone consisting of a series of reticulations of laumonite.

Up to this period the sandstone and conglomerate were supposed by many to afford the best mining-ground, and that to this source they were to look for permanent supplies of the sulphurets of copper. During the winter of 1845–'46, some German miners, in clearing away the talus near the base of the cliff,

discovered a small loose specimen of mass copper. This stimulated them in their researches, which resulted in the discovery of the vein in the belt of granular trap about twelve feet to the east, showing that it had been subjected to that amount of heave or dislocation. * * * * From that time to the present day, hardly a month has elapsed without developing new masses; and their occurrence, so far from creating wonder, is regarded as a matter of course. The largest single mass hitherto exposed weighed about fifty tons. * * * * *

From the reports of the trustees rendered in 1849 and 1850 we gather the following information:

The amount of capital stock paid in by the stockholders is $110,000. The personal effects of the company on the first of December, 1848, were $140,982, leaving a surplus of $111,105 —a sum a little more than equivalent to the entire capital stock. This statement does not include the mine, with its fixtures and improvements, such as the stamping-mill, furnace, &c. * * * *

	Products.	Expenses.
1846 - -	$8,870,95	$32,203,44
1847 - -	70,977,32	61,737,85
1848 - -	166,407,02	67,667,58
1849 - -	244,237,54	106,968,77

This embraces such expenses only as were incurred at the mine; those of insurance, commissions, freights, &c., are excluded. The cost of transportation to Boston is $15 per ton; to Pittsburg, $7,50. The incidental expenses amount to about 20 per cent., in addition to those of mining.

The company have erected the necessary works at Pittsburg for smelting and refining the copper, and they estimate that the shipments for the year ending December, 1849, will amount to 660 tons of refined copper.

The product of silver for the year 1849 was $2,365,30."

ART. XXVI.—*Effects of Lightning during a storm on the first of July*, 1851, *at Attleboro', Mass.;* by Mr. HENRY RICE.

ON the 1st of July a thunder storm commenced in the S.W., at about 6¾ A.M., the wind being at the time in the south. At 7½ A.M. the wind had changed into the S.W. At a little before 8 o'clock the shower seemed to divide, one part going to the north and the other to the south of this place. At 8 A.M. the wind had changed into the east, the clouds at the same time coming from the south. At 8¼ it commenced raining here, the shower which was at the south having come up and the wind having changed into the south. One flash of lightning which seemed to go directly downwards, was succeeded by the report in eight seconds, and the report continued audible for thirty seconds, hence

we may suppose the distance of this flash to have been about 1¾ miles; this I think was as near as any to this place.

At a distance of about four miles south of this place, the lightning struck the upper telegraph wire and passed off in both directions, giving reports as loud as that of "a pistol fired in a close room," in the telegraphic offices in Boston and Providence. The lightning split or splintered nearly all the posts for about one mile, and broke several of the glass insulators. The most southern post which was affected by the lightning is situated about four miles south of this place; calling that post 1, and numbering all the posts which have been affected, I find the last one split is No. 28. Nos. 9, 24 and 27 are not injured in any way. No. 18 is split the most of any; this post stands in a very wet place, in fact it is surrounded by water. Nearly every post that was affected had a long, narrow spiral groove dug out along its whole length, corresponding with the grain of the wood. Post No. 18 was split into three nearly equal pieces, the iron spikes torn out and the upper insulator broken. Persons living near the line of the telegraph say they saw the flash as it passed along on the wires; they also heard several slight reports similar to those of percussion caps.

As the shower passed on to the east, the lightning struck a house belonging to Mr. Ebenezer Draper, situated in the village of Attleboro', known as "Attleboro' City." This house was struck twice, the second discharge being about three minutes after the first. There was no lightning rod on the house, and the nearest one to the house was situated about fifty rods distant. There are, I believe, but three rods in the village, or within ¼ mile of the house. This house is a one-story frame building, standing upon a stratum of graywacke conglomerate soil of the red slaty variety, and has been built 50 or 60 years. The house fronts the road which runs through the village in a N.E. and S.W. direction. At each end and within four feet of the house stands a Balm of Gilead (Populus candicans). These trees are very much branched, but the branches of the tree at the N.E. end of the house do not extend over the house to any considerable extent. There were four persons in the house at the time it was struck, viz., Mr. Ebenezer Draper and wife and daughter, and Mr. Daniel Barney.

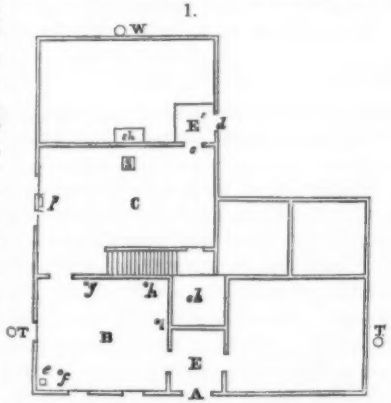
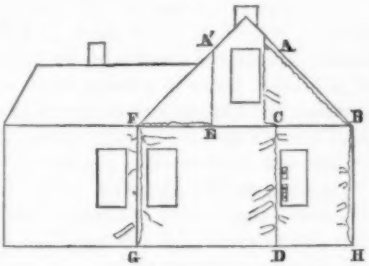


Fig. 1, on preceding page, represents a ground plan of the premises: A, front door which opened into the entry E; B, front room; C, kitchen; *ch*, chimney; *e*, old fashioned clock, reaching from the floor near to the ceiling; *f*, seat of Mr. Draper by the clock; *g*, seat of Mr. Barney; *h*, seat of Mrs. Draper; *i*, seat of Mr. Draper's daughter; S, stove; *c*, door leading out of the kitchen into back entry E′; *p*, post on which hung a mirror; T, T, Balm of Gilead trees; W, well.

The house was first struck at A, fig. 2, whence the fluid passed into the house and divided; a part going down the stud A C, and thence down the stud C D to the ground; the other part went down the rafter A B, and thence down the post B H, to the ground. The part which went down A C ran along the stud from A till it came to a long iron spit about three feet long, down this it passed to its point which rested on the beam F B, thence along the beam a short distance to the stud C D, down which it went, tearing off several clapboards in its progress on the outside of the house, and the laths, plastering and paper, beside the window, on the inside. It also broke from the window three lights of glass, throwing the glass *into* the house. The white oak stud C D was split its entire length, the fluid following the rows of nails which fastened the laths, clapboards, &c. That portion of the fluid which went down the rafter A B split off the weather board from the rafter, then passed down the post B H a short distance till it came opposite the wheel-work of the tall old fashioned clock which stood in the corner at *e*, fig. 1. From the post it passed to the top of the clock to the wheels, tearing off the upper part of the clock-case and throwing it into the middle of the room B, fig. 1. From the wheels, it passed down the long iron pendulum, thence through the bottom of the clock-case into the corner of the house and into the ground. The glass in the upper part of the clock-case was broken, and the case at the bottom was badly splintered, but the clock was not stopped.

2.



VIEW FROM THE N. E.

Mr. Draper, who was sitting in the chair at *f*, fig. 1, was prostrated by this part of the shock into the middle of the room, on his face. There was no visible mark of injury on him at the time, although he complained at first of numbness in his lower limbs, then of a severe burning sensation in his feet, and requested that his "boots might be taken off, for his feet were burning up."

There was a bruise at the corner of his left eye and another on the back of his right hand, but these he thinks were not made by the lightning. The clothes which he had on at the time were entirely of cotton and were uninjured. The room was immediately filled with a very strong smell of sulphur. There was a small hole made in the back right-hand corner of the flag-bottomed chair in which Mr. Draper sat. No other person in the room was in the least injured by this stroke.

It appears that a part of the fluid passed down the tree situated at that end of the house. The first visible effect of the lightning on this tree is on one of the limbs about twelve feet from the ground, where a little bark is torn off; from that spot to the trunk, occasional marks of its progress are visible; on the trunk of the tree, there is a seam split in the bark about four feet in length. Mr. Draper's right foot was very much swollen on the next day, when I saw it; he attributes this to his first shock. These I believe are the principal details relative to the first shock.

As soon as Mr. Draper's boots were off and he had somewhat recovered the use of his limbs, he was assisted by those present into the kitchen, Mr. Barney being on his left side and his wife and daughter on his right. As soon as he was seated in a chair (about four feet from the post *p* (fig. 1,) in the kitchen, the second flash came and prostrated all four of them. This flash struck the house on the roof, close to the edge and directly over the rafter at A′, fig. 2, where there were four iron hooks hanging; from these it passed down the stud A′ E, on which was hanging a long iron rod; thence it went to an iron pan which rested on the beam, leaning against the side of the house; from the pan it ran along the beam in the direction E F, fig. 2, till it came to the post F G, (*p*, fig. 1,) down which it went, tearing off the casing on both sides, breaking to atoms a mirror which hung on the post, splitting the post, which was of white oak, its entire length, tearing off the laths on both sides of the post on the inside of the house, and the clapboards on the outside; it then passed into the floor, after which but few marks of its progress are to be seen. There are a few places over-head in the kitchen where the plastering is torn from over the nail-heads. A few splinters are torn from the floor of the entry which leads out of the kitchen, and some out of the kitchen floor, near to the door of the entry.

The effect of the stroke upon Mr. Draper's daughter, although she is a lady about 45 years of age and in very feeble health, was but slight; and being merely stunned she soon recovered. Mr. Draper was also stunned, and more so than at his first shock; but he thinks he received no additional injury.

The effect upon Mrs. Draper and Mr. Barney was more severe. A portion of the fluid passed from the post *p*, fig. 1, to Mr. Barney, (he being nearest the post and distant about four feet,) strik-

ing him on the outside of his left hip, then running round on the front of his hip in a spiral manner to the inside of his left leg, ripping open the inner seam of the left leg of his pantaloons for about eight inches as it passed down his leg. It tore off a piece of skin above the ankle, then passed over the ankle and tore off the skin from just below the ankle to the first joint of the great toe, where it passed out through the boot, tearing out a ragged, nearly round piece of the size of an American dollar. Another portion passed out nearer the heel, making a ragged slit two inches in length. Fig. 3, represents the appearance of Mr. Barney's boot. The piece of leather was not detached on the upper side. He had on no stocking at the time. Mr. Barney was the first of the four who came to a state of sensibility; he immediately crawled to the door *d*, fig. 1, and called for assistance (there being a house within about three rods.) He at first complained of an intense burning sensation, and requested that his boots might be taken off. The foot, on taking off the boot, was found to be very black, and the leg above was colorless and numb, and for half an hour appeared like the limb of a dead person. The hip and whole leg along the track of the fluid, was very much scorched; and when I saw it the next day, about 5 P. M., the muscle under the track of the fluid was somewhat shrunken in appearance, and the skin very red.

3.

Mr. Barney says he heard the report but saw no flash. He had been at work in a field near the house of Mr. Draper, and seeing the shower coming up, went into the house to be out of the rain; he thinks he got into the house before it commenced raining, and that his clothes were perfectly dry unless his perspiration might have moistened them. His pantaloons were a pair of blue and white overalls. The *stitches* and not the cloth were ripped out at the knee.

Mr. Barney says that his wound "does not feel like a common burn but more like a scald." He says that he "has for some time past been troubled with a severe cough and soreness in his lungs, but that since he received the shock, he has not felt so sore at his lungs and his cough is much better."

Mrs. Draper (an old lady now in her 80th year) also received a portion of the fluid which came from the post *p*, fig. 1. She was in a state of insensibility for half an hour, although as soon as assistance could be procured, means were used to resuscitate her.

She was first struck on the back of her neck; the fluid there scorched the hair, then ran round her neck on a string of gold

beads which she had on at the time. Each bead must have been enveloped in the fluid, I think, as it passed around her neck, for the position of each bead was distinctly marked by a black spot on her neck, and the number of these black spots correspond with the number of beads. The effect of the fluid on the beads was to turn them black. She had in her ears at the time a pair of gold ear-nubs;—the one in her left ear had a spot on it similar to what would be made by putting strong acid on brass; it looked black and corroded. From her neck the fluid passed down her left side to her feet, leaving but one mark of its progress, and that was at the lower part of her chest on her left side; the skin there was somewhat bruised and blackened but not broken. Her left foot, when I saw it, was very much swollen, but was not bruised, neither did she complain of any soreness. Her sensations on coming to were the same as those of the others; an intense burning sensation in her feet "as though her feet were in the fire." She had on at the time a thin cotton dress, which was not in the least injured by the stroke. There was no rent made either in her stockings or shoes.

I believe I have now detailed the principal effects upon the several individuals; there are however some further particulars worthy of notice.

There were no marks made by the lightning on the kitchen floor where the four individuals were prostrated. There were no marks of the lightning near the stove, which was but about four feet from where the four individuals were standing at the time of the second shock. In the cellar little damage was done, except to remove the mortar from between the stones. In the chambers or attic above, there were several articles of iron furniture stowed in the end near to where the house was struck. Within four feet of where the lightning passed down the stud A′ E, fig. 2, there stood an air-tight stove which did not seem to have been in the least molested by the lightning. An old umbrella which lay at the foot of the stud A′ E, was set on fire but none of its metallic fixtures were melted.

The silvering on the back of the mirror which hung on the post *p*, fig. 1, did not seem to have been in the least affected by the electricity; still the frame of the mirror was very much shattered. The electricity, wherever it went, appeared to have made a very diligent search for nails, screws, hinges, &c., and wherever it found them, it either tore them out or split the wood around them.*

North Attleboro', July 18, 1851.

* In the passage of electricity, the effects of violence are to be found mainly where the current is interrupted. A good metallic conductor, or masses of iron together would receive the fluid and might show no effects, but ranges of nails or spikes would give rise to a shock between them and consequent violence.—Eds.

Art. XXVII.—*On the former Changes of the Alps;* by Sir Roderick Impey Murchison, V.P.R.S.*

The complicated structure of the Alps so baffled the penetration of De Saussure, that after a life of toil the first great historian of those mountains declared "there was nothing constant in them except their variety." In citing this opinion, Sir Roderick explained how the obscurity had been gradually cleared away by the application of modern geology, as based upon the succession of organic remains, and then proceeded to indicate the accumulations of which the Alps were composed, and the changes or revolutions they had undergone, between the truly primeval days when the earliest recognizable animals were created, and the first glacial period in the history of the planet.

The object being to convey in a popular manner clear ideas of the physical condition of these mountains at different periods, three long scene-paintings, prepared for the occasion, represented a portion of the chain at three distinct epochs. The first of these views of ancient nature exhibited the Alps as a long, low archipelago of islands, formed in a great part out of the Silurian and older sediments which had been raised above the sea, when the lands bore the tropical vegetation of the carboniferous era.

Stating that there were no relics in the Alps of the formations to which he had assigned the name of Permian, as marking the close of the primeval or palæozoic age, Sir Roderick rapidly reviewed the facts gathered together by many geologists from all quarters of the globe, and maintained that they unequivocally sustained the belief, that there had been a succession of creations from lower to higher types of life, in ascending from inferior to superior formations. He carefully, however, noted the clear distinction between such a creed, as founded on the true records of creation, and the theory of the transmutation of species; a doctrine put forth in the popular work entitled the "Vestiges of Creation," and from which he entirely dissented.

In the second painting (an immense lapse of time having occurred) the Alps were represented as a mountainous ridge in which all the submarine formations, from the mediæval up to the older tertiary or Eocene, had been lifted up upon the flank of the primeval rocks. Each rock system being distinguished by a color peculiar to it, the nature of the animals contained in each of these deposits was succinctly touched upon. Between the youngest of the primeval formations and the oldest of the mediæval or secondary rocks, it was stated, that there is not one species in common to the two in any part of Europe; the expression being

* Proc. Roy. Soc., March 7, 1851, p. 81.

that "an entirely new creation had succeeded to universal decay and death."

In speaking of the Alpine equivalents of the British Lias and Oolites, Sir R. paid a deep-felt tribute to Dr. Buckland, who thirty years ago had led the way in recognizing this parallel; and Leopold von Buch was particularly alluded to as having established these and other comparisons, and as having shown the extent to which large portions of these mountains have been metamorphosed from an earthy into a crystalline state. In treating of the cretaceous system it was shown that the Lower Green Sand of England, so well and so long ago illustrated by Dr. Fitton, was represented in the Alps by large masses of limestone, since called Neocomian by foreign geologists.

Emphasis was laid upon the remarkable phenomena, that every where in the south of Europe (as in the Alps) the Nummulite rocks, with the 'flysch' of the Swiss, and the 'macigno' of the Italians, have been raised up into mountains together with the Hippurite and Inocerami rocks, or the chalk on which they rest; and hence it was, that before Sir R. made his last survey of the Alps, the greater number of geologists classed the Nummulite rocks with the cretaceous system, and considered them both to be of mediæval or secondary age. But judging from the fossils which differ entirely from those of the chalk (except at the beds of junction) and also from their superposition, he had referred these Nummulite rocks to the true lower tertiary or Eocene of Lyell. Beds of this age, though once merely dark-colored mud, have been converted into the hard slates of Glarus with their fossil fishes (among which eels and herrings first made their appearance); other strata of this date contain the well known fishes of Monte Bolca; and others again have been rendered so crystalline amid the peaks of the Alps as to resemble primary rocks, so intense have been the metamorphoses!

Dwelling for a few minutes on the atmospheric conditions which prevailed after the elevation of the older tertiary, Sir R. inferred that a Mediterranean and genial climate prevailed during all the long period whilst the beds of sand (Molasse) and of pebbles (Nagelflue) were accumulating under the waters both of lakes and of the sea, and when derived from the slopes of all the pre-existing rocks. The marine portions of the Molasse and Nagelflue contain the remains of many species of shells now living in the Mediterranean; whilst in alternating and overlying strata, charged exclusively with land and fresh water animals, not one species among many hundreds, including numerous insects, is identical with any form now living. This point, on which he first insisted on his return from the Alps in 1848, Sir R. had considered to be of paramount importance in proving, that terrestrial life was much less endowed with the capacity to resist physical

changes of the surface than submarine life: for here we have a fauna which is Pliocene in the order of the strata, and yet is not Eocene in its animal and vegetable contents.

A certain number of the more remarkable animals that lived during this younger tertiary age were then adverted to, such as the Rhinoceros and other large quadrupeds, the fossil Viverrine fox (the original of which was on the table,) the huge Salamander (Andrias Scheuchzeri) and a Chelydra which had been described as analogous to the snapping turtle of the southern states of North America. These, with quantities of plants, including small palms, were all indicatives of a warm and genial climate; and on such sure grounds the second diagram placed the Alps before the spectators as covered with a suitable vegetation, and with several of the above mentioned animals in the foreground.

Having satisfied himself, in common with M. Studer, M. Escher, and all the geologists who have well explored the Alps, that every where along the northern flank a terrific dislocation has occurred, amounting in many places to a total inversion of mountains, between the older tertiary and those younger deposits which were accumulated under the waters during the period he had just been describing, Sir Roderick then briefly pointed out what he had demonstrated in detail elsewhere: viz. that the sands and pebble-beds of that age had been suddenly heaved up from beneath the waters all along the outer or northern flank of the chain, so as to form mountainous masses, the inverted and truncated ends of which had been forced under the edges of the very rocks out of whose detritus they had been formed.

Before this great revolution had taken place, no large erratic blocks were known, but after it, they became common, and were the necessary production of that intensely cold climate to which the Alps were then subjected; a change, of which their surface bears distinct evidence.

During the same period, the low countries of northern Europe were covered by an Arctic sea. If such waters then extended to the Jura and the Alps, icebergs and rafts must have been detached from the latter, carrying away blocks of stone northwards, to be dropped at intervals, just as it has been demonstrated that the Scandinavian blocks were dropped in Prussia, Poland, and the low lands of Russia, when all those regions were under the influence of an Arctic sea. Bavaria, and the lower parts of the Cantons Vaud, Neufchatel, and Berne, were, it is supposed, then covered by waters which bathed the foot of the Alps.

That the change from a former genial climate to the first great period of cold was a sudden one is further sustained by the fact, that the inclined strata in which the Mediterranean animals are buried, are at once covered *transgressively* and *unconformably* by other beds of gravel, shingle, and mud, in which the remains of plants and animals are those of a cold climate.

The third scene, therefore, exhibited the sands and pebbles of the genial period thrown up into mountains on the flanks of the chain, the peaks of which were probably covered for the first time with snow, and from the openings of which, whether protruding to the sea-shore or into deep fiords or bays, glaciers and their moraines advanced, from which icebergs or rafts were floated away as suggested.

In concluding Sir Roderick thus expressed himself:—"Having thus now conducted you rapidly through the most prominent changes which the Alps have undergone, from the first period when they had emerged, probably as an archipelago of low islands in a tropical climate, to that epoch when the animals and plants living upon them indicated a Mediterranean temperature, and then to that Arctic period, the conditions of which I have just been discussing, I have no longer to call for your assent to any inferences of the geologist, which all of you are not perfectly competent to understand.

"To convert the Alps of the earliest glacial period into the Alps of the present day, you have only to figure them to yourselves, as raised 2000 or 3000 feet above the altitude which they are supposed to have in the diagram last exhibited. All their main features remaining the same, you would then have before you, the present Alps and their valleys, irrigated by lakes and rivers instead of bays; and in place of the waters sketched in beyond them as in the painting, with ice-bergs floating upon them, you will then have dry mounds of gravel, sand, and blocks, which were accumulated under the former waters; such, in a word, as now constitute low hills and valleys and all the richest land of Switzerland and Bavaria, where man has replaced the rhinoceros and turtles of one period, and the icebergs of another. You who have not visited this noble chain, and who wish to judge of its gorges, peaks, and precipices, have only to consult the views of our associate Brockedon, in order to have nature in her present mood, brought in the most telling manner before you. But those of you who really wish to grapple with the geological wonders of former days, may look at the flanks of the Rigi from the lake of Lucerne, whence, even from the deck of the rapidly passing steamer, you will see how that great pile of pudding-stone, every pebble of which has been derived from rocks in the chain more ancient than itself, has been lifted up from beneath the waters in the manner represented; whilst if you continue the same traverse up the Lake to Altorf, you will pass by numerous extraordinary folds and breaks of the secondary limestones, and of the older Tertiary or Nummulitic rocks. Such a doubling or crumpling up of these strata, you may then perchance agree with me in thinking, was in a great measure the result of lateral pressure between two great masses; the crystalline centre of the chain upon the south, and the newly upraised deposits on

the north of which the Rigi is a small part only, which latter having been intruded upon the terrestrial surface, necessarily compressed the pre-existing formations into a smaller compass. If more adventurous, you should climb to peaks rising to 8000 or 9000 feet above the sea, that flank the central summits, you may there satisfy yourself, that deposits, which were once mere mud, formed during the same time as our slightly consolidated London clay, have been in many parts converted into schists and slates as crystalline as many of the so-called primary rocks of our islands. So intense has been the metamorphosis!

"In speaking of the last changes of the Alps as stupendous, I know it may be said that, in reference to the diameter of the planet, the highest of these mountains and the deepest of these valleys are scarcely perceptible corrugations of the rind of the earth. But when we compare such asperities with all other external features of this rind, they *are* truly stupendous. How, for example, can the observer travel over vast surfaces such as Russia, and not be able there to detect a single disruption—not one great fracture, and no outbursts whatever of igneous and volcanic rocks; but on the contrary, a monotonous and horizontal sequence of former aqueous deposits, which, simply dried up, have never been disturbed by any violent revolutions from beneath, and then compare them with the adjacent Ural mountains, or still better with the loftier Alps, and not be impressed with the grandeur of such changes?

"And here my auditors will recollect, that even beneath and around this metropolis they can be assured by finding extinct fossil mammalia, that such also have been the changes, though on a less scale, in our own country. The large extinct British quadrupeds necessarily required a great range for their sustenance. They had doubtlessly roamed from distant tracts to our lands before the straits of Dover were formed and before the British dominions were broken into isles. Our great insular dislocations were, I conceive, coincident with that striking phenomenon in the Alps on which I have tried to rivet your attention, when the first glacial and icy period affected so large a portion of this hemisphere, and when large portions of our northern lands formed the bottoms of an Arctic sea. But such tracts were bidden to rise again from beneath the waters and constitute the present continents and islands before man was placed on the surface. Our race, in short, was not created until the greater revolutions of which I have treated had passed away.

"These grand dislocations belong, therefore, distinctly to former epochs of nature, and their magnitude *is* enormous when compared with any thing which passes under our eyes, or has been recorded in human history. At the same time geologists have shown upon clear evidences, that during the long and com-

paratively tranquil former period which intermitted with geological revolutions, there was a constant exhibition of diurnal agencies similar to those which prevail in the present world. In those older times, rain must have fallen as now,—volcanic forces must have been active in scattering ashes far and wide, and in spreading them out together with sheets of lava beneath the waters,—gradual movements of oscillation and moderate elevations and depressions must have occurred,—long continued abrasion of the sides of mountains must have produced copious accumulations of 'débris' to encroach upon lakes, the overflow or bursting of which may have sterilized whole tracts.

"All such and many more modifications of the ancient surfaces of the globe, including many slight breaks in the long career, were doubtlessly common to all epochs. But whilst no such operations can be compared with those phenomena of disruption and overturning of mountain masses which have been specially dwelt upon this evening, so also according to my view it is impossible, that any amount of small agencies, if continued for millions of years, could have produced such results.

"In thus attempting to shadow out in the space of an hour all the chief formations and transmutations of a chain like the Alps, I have probably labored to effect what many persons may deem impossible; but I have thought that some at least of these evening discourses should awaken the mind to the larger features of each science, the details of which must be followed out in courses of lectures. I would beg, therefore, those persons who have not studied geology practically, to dwell chiefly on the facts brought forward, and to believe that they are indisputably and clearly proven. They tell us unmistakably how different creations of animal and vegetable life are entombed in these vast monuments of ancient nature, and they reveal to us that each creation of the successive inhabitants of the surface lived during very long periods of time. They announce to us, in emphatic language, how ordinary operations of accumulation were continued tranquilly during very lengthened epochs, and how such tranquillity was broken in upon by great convulsions.

"Being thus led to ponder upon the long history of successive races and also upon some of the most wonderful physical revolutions the chain has undergone, we cannot avoid arriving at the belief, that, in addition to many other great operations, the disruption which upheaved the middle and younger Tertiary formations from beneath the waters, and threw them up into mountain masses accompanying the production of the first great arctic period known in the history of the planet, was a change of immeasurable intensity. That change, in short, by which a period of snow, ice, glaciers, floating icebergs, and the transport of huge erratics far from the sources of their origin, suddenly followed a genial and Mediterranean clime!"

Art. XXVIII.—*Observations on the Pendulum Experiment;* by Rev. C. S. Lyman.

Every one who has repeated the interesting experiment of M. Foucault for exhibiting the rotation of the earth, has noticed the tendency of the pendulum, after vibrating awhile apparently in a straight line, to acquire gradually an elliptic motion. The quantity of this ellipticity in different experiments is very variable, some observers having found it to amount occasionally to half an inch or an inch for the minor axis, when the pendulum was left to vibrate for a considerable time. If the experiment, however, is skillfully conducted, the degree of ellipticity will always be small, and when it is not so, it may safely be attributed to imperfections in the apparatus, currents of air, lateral vibration of the pendulum at the moment it is disengaged, or other like sources of disturbance. In our own experiments, to which we shall again refer, with an apparatus by no means answering to our wishes, the minor axis of the ellipse rarely exceeded two-tenths of an inch, with an initial arc of vibration of about four feet, and in some trials no ellipticity was perceptible for the first two hours. Whether it is possible to conduct the experiment so skillfully as entirely to avoid these sources of error, and cause the pendulum to vibrate without any observable ellipticity arising from such accidental causes, is very doubtful. Certainly no one has yet succeeded in doing it.

But even if the conditions of the experiment were theoretically *perfect*, that is, the apparatus free from all defect, and uninfluenced by accidental disturbing causes, still the ball would never move in a straight line from side to side, but always necessarily describe an ellipse, in consequence of the rotation of the earth itself. It seems to have been taken for granted by those who have written on the subject, that, in theory, the pendulum ball at each vibration should pass accurately through its point of rest, or a vertical straight line drawn from the point of suspension to the center of the earth. And this is stated in so many words on page 562, vol. i, No. 7, 4th ser. of the Philosophical Magazine, in remarks by Rev. Baden Powell before the Royal Institution. That this would be true had the earth no rotation on its axis, is obvious. But a little reflection will make it evident that in existing circumstances, such can never be the case.

Suppose, to simplify the problem, the experiment to be performed at a pole of the earth. The point of suspension of the pendulum, and the center of the circle over which the pendulum vibrates, being in the line of the earth's axis are unaffected in position by the earth's rotation. But the circumference of the circle, and with it the pendulum ball when drawn aside and de-

tained over it previous to being let off, obviously partake of the earth's motion of rotation, making a complete revolution around the pole, or center of the circle in twenty-four hours. The pendulum ball has thus a certain momentum, or amount of motion at right angles to the plane of vibration, at the moment it is disengaged; which motion, during the time the ball is descending from the circumference to the center of the circle, must carry it to the right hand, or aside from that center by a space corresponding to the tangential velocity it possessed at starting. Continuing its curvilinear motion under the action of gravity and the tangential force referred to, it proceeds by the laws of central forces to complete approximately an ellipse, with the point of rest for its center.

The same elliptical motion which would thus necessarily exist at the poles, must occur likewise on any other part of the globe, except at the equator. For in any given latitude, it is easily demonstrated, that the graduated horizontal circle across which the pendulum vibrates, possesses a virtual motion of rotation in azimuth about the vertical, in consequence of the earth's rotation—the amount of its angular motion in a given time being equal to the angular motion of the earth on its axis in the same time multiplied by the sine of the latitude, as has been shown by many writers on the subject.

This relative azimuthal motion of the horizontal circle around its center, is precisely that of which the ball partakes at the moment it is disengaged, and from which must arise a necessary ellipticity, just as in the case at the pole, only less in amount by as much as the sine of the latitude is less than radius.

Perhaps this motion may be more readily conceived, by considering, that points on the earth's surface rotate eastward with different velocities as they are at a greater or less distance from the equator; consequently, that the south point of the horizontal pendulum circle moves eastward with a greater velocity than the center, so that when the pendulum ball is released from that south point, retaining the full amount of its eastward motion, instead of passing directly through the center, or point of rest, it must leave it behind, passing it to the eastward by a space equal to the difference of the motions of the two points during a semivibration.

The same will hold true in whatever direction the pendulum is made to vibrate. For, suppose the ball drawn to the eastern side of the circle: though in this case the actual rotary velocities of the center of the circle and of this eastern point of it are the same, considered as around the earth's axis, yet considered as around the vertical, with which in these experiments we have to do, they are quite different. It has already been shown that the *south* point of the circle has a relative azimuthal motion in re-

spect to the center. The east point, being constantly at right angles to the south point, must consequently have a like relative motion. And so of every other point in the circumference of the circle. Hence, from whatever point the ball is let off, it must possess a tangential motion relatively to the center, and therefore move in its vibrations in an elongated ellipse.

Nor are we to regard this necessary ellipticity, though minute, as too small for detection, where the experiment can be carefully performed under favorable circumstances—particularly with a long pendulum, and a large arc of vibration.

Suppose the pendulum 208 feet in length, making a vibration in 8 seconds or a semi-vibration in 4 seconds. Suppose the arc of vibration 20 feet, or the radius of the circle 10 feet. A point in the circumference of this circle would, in the latitude of New Haven, have a motion relatively to the center of 40″ of arc in 4 seconds of time, or a semi-vibration; which 40″ on a circle of 10 feet radius will be equal to 0·022 of an inch. Thus giving for the minor axis of the ellipse double this quantity, or nearly the twentieth of an inch. This space would doubtless be readily appreciable in a delicate arrangement of the experiment on the scale supposed; or if not appreciable at once by direct observation, would be likely to develop itself, as experiments were multiplied, by showing the elliptical tendency to be in one direction rather than the other.

The ellipticity arising from the earth's rotation must, as we have seen, always be towards the East, or in a direction opposite to that of the hands of a watch. But the ellipticity observed in the experiments is in both directions—showing that in general it must be owing to other causes than the one specified. Indeed, in the ordinary experiments, with pendulums comparatively short, and a small arc of vibration, this ellipticity must be entirely inappreciable by direct observation. It can only become obvious, if at all, in experiments on a large scale; and so far as appears, persons who have conducted such experiments have not had their attention drawn to this particular point. It is partly with a view to invite the attention of more favored experimenters to the subject, that this article has been written and the results given of our own imperfect experiments.

These experiments were instituted in part, to determine whether the ellipticity of which we have spoken could be made appreciable by the facilities within our reach. The pendulum we have used is a cylinder of lead on a iron axis, very accurately turned, and weighing 12 pounds. This is suspended by a fine brass wire soldered at its upper extremity into a brass bolt inserted in the apex of the dome, or skylight, of the State House in New Haven. The length of the pendulum is 71 feet, (vibrating once in $4\frac{2}{3}$ seconds,) and the diameter of the graduated circle placed beneath

it 36 inches. Owing to the closeness of the entire apartment, little or no trouble was experienced or apprehended from aerial currents.

Without giving the experiments in detail, we will only mention some of the results.

The pendulum was usually set vibrating with an arc of about four feet, which in half an hour became reduced to 28 inches, in an hour to 19 inches, in an hour and a half to 14 inches, in two hours to 10½ inches, in three hours to 6½ inches, and in four hours to 4⅓ inches. In general the duration of the experiments was not much over an hour, often much less, occasionally three or four hours.

As to the amount of ellipticity, there were but two instances out of over thirty in which none could be perceived. In several other cases it was barely perceptible after the lapse of two or three hours, and in but one instance exceeded two-tenths of an inch for the minor axis. In general it was less than one-tenth of an inch at the close of the experiment.

As to the motion in the ellipse, it was by no means always in the same direction, and hence could not be due exclusively, at least, to the influence of the earth's rotation. It seemed rather to depend on some imperfection of the wire at the point of suspension, or some other defect of the apparatus, inasmuch as it appeared to have a pretty uniform connection with the direction across the circle in which the pendulum vibrated. For example, six times when that direction coincided with the meridian the motion in the ellipse was with the hands of a watch. The same number of times when put in vibration at right angles to the meridian, the motion was in the contrary direction. When vibrating from N.E. to S.W. the motion was with the hands; when from N.W. to S.E. the reverse. And these results were nearly uniform while the point of suspension retained a given position in reference to the points of the compass, but when that position was altered, the points at which a given direction of elliptical motion was observed were changed also; showing, as before remarked, that the direction of elliptic motion was connected not with the rotation of the earth, nor with the points of the compass, but with something in the apparatus itself; and it probably depended not on any imperfection in the ball of the pendulum, but in the wire above at the point of suspension. The necessary ellipticity of rotation was not detected in these experiments, being doubtless over-balanced and lost amid the more efficient causes of ellipticity arising from accidental sources.

As to the rate of angular deviation of the plane of vibration on the graduated circle, this was observed to be obviously affected by the direction in which the pendulum moved in its elliptic orbit—being accelerated when that motion coincided with the

motion of the plane of vibration, and retarded when the reverse; and the amount of this acceleration or retardation was not constant in a given case, but increased as the arc of vibration diminished and the ellipse became less eccentric. Sir John Herschel has shown* that when a pendulum, as in these experiments, moves in an ellipse, the line of apsides of that ellipse will necessarily have a progressive motion in the same direction in which the pendulum revolves; and this motion will be more or less rapid according to the angular extent of the arc of vibration. When that angle is indefinitely small, the sines of the angles made by the pendulum wire with the perpendicular, which sines represent the intensity of the central force by which the motion of the pendulum is governed, will be nearly in the proportion of the arcs themselves, and the line of apsides of the ellipse will remain immovable. But when the arc of deviation from the vertical is considerable, the sines cease to be proportional to the arcs, and as the pendulum approaches the extremity of its vibration, being acted on by a diminished central force, it is suffered to go past the point on the circle at which in the preceding revolution it turned the extremity of the ellipse, before it is brought to do the same again, and hence the line of apsides must revolve in the same direction. This accords with our experiments.

The mean hourly motion of the plane of vibration, when the direction of the elliptic motion coincided with it, was 10° 11′. When it did not coincide, 9° 44′—giving a mean hourly motion of 9° 57′. The theoretical hourly motion in the latitude of New Haven would be 9° 54′. This amount of motion as deduced from experiment would doubtless have been somewhat modified had the experiments been more numerous, and they are only here given as a first approximation. The numbers show very clearly, however, the accelerating and retarding effect of the elliptic motion.

It should be remarked, that if the necessary ellipticity which we have considered to arise from the earth's rotation has any influence on the results of experiments, it should tend slightly to retard the motion of the plane of vibration, inasmuch as being always in the direction of the earth's rotation, it should give the line of apsides of the ellipse a motion in the same direction; which motion would have to be deducted from the motion of the plane of vibration in the opposite direction. Whether accurate experiments will show such a retardation remains to be seen. So far as experiments have been tried, in some cases, as at Paris, they seem to indicate such a result, while in other cases they do not.

* Outlines of Astronomy, p. 421, Am. Ed.

Art. XXIX.—*Miscellaneous Notes, from Europe;* by B. Silliman, Jr.

1. *Present condition of Vesuvius.*

The eruption of Vesuvius in February, 1850, and that of the year previous, entirely changed the summit features of this ancient mountain of fire. The former crater disappeared, being filled with scoria and ashes, while *two* craters now occupy the summit of the cone. The deepest and most active of these is that of February, 1850, which is situated on the side of the cone nearest to Pompeii. It is somewhat lower and has a much greater depth than its immediate neighbor, which is on the side of the bay of Naples. We had no means of measuring its depth accurately, but judging from the time required for the returning sound of a stone cast into its mouth, as well as from inspection and comparison, we assumed the depth of the new crater to be from 800 to 1000 feet. It is acutely funnel-shaped at an angle of not less than 60°. It is impossible, because of the steam and vapors of sulphurous acid, to see its bottom, even if not prevented by the danger of the descent to a position where one might hope to catch a glimpse of its bottom. Its activity at present is confined to the emission of vapor, and even this seems at times, when viewed from the sea, to be wanting. On the summit, however, these vapors appear dense enough and are sufficient to prevent the possibility of making the entire circuit of the crater. From this cause we were unable to examine the lip dividing the crater of 1850 from its neighbor. The observer is much struck not only with the change of form in the summit as shown by the drawings of Prof. Scacchi, but also with the sharpness of the lip of both craters, which is such that it is hardly possible for more than two persons to stand abreast upon it. During the late eruption, the lava found vent from the base of the cone on a level with the sand plain which fills the ancient crater of Somma. It here poured out a torrent of scoriaceous red lava through a well defined canal. This is now entirely cold, and we collected from its sides abundant specimens of aphthitalite, which frosted over the rugged cavern like snow. Near this spot also are two fumeroles formed during the last eruption; the largest about 25 feet high, with an aperture of near ten feet, its outer walls black, rugged and forbidding. The flow of lava from the eruption of 1849 was in the direction of the ancient Pompeii, and it was copious enough to destroy a small village with its vineyards, at the distance of several miles. The king of Naples has since erected a new village for the unfortunate inhabitants near the site of the former one.

During the past six years the king of Naples has also constructed a carriage road up the side of Vesuvius as far as the Hermitage, where he has a Royal Meteorological Observatory, under the direction of the celebrated Melloni. This road follows in a very serpentine path over and around the hill of ashes, which all who have seen Vesuvius will remember as forming a remarkable feature in its topography. In this manner, sections have been opened in the hill for a distance of three or four miles, and were these viewed without reference to the immediate

proximity of the volcano which has produced the deposit, it would be easy to refer the whole to an alluvial origin, so characteristic are the undulating lines of deposition, the alternation of coarse and fine materials interstratified, including now large angular masses of rock, and again graduating into the finest silt and mud. In some places the lines of deposition are curved in regular undulations, and in others they meet at a sharp unconformable angle. Close observation alone detects that the whole material is volcanic—pumice, scoria, sand and fine dust, including large blocks of inflated lava and tufa.

It is impossible to see any difference in the general character of these deposits and of those which cover Pompeii, only that the latter being mostly the result of one eruption are less varied than the former, and more regularly stratified. In both, the evidence of aqueous action is very obvious; and we have historical as well as geological evidence of the eruption of vast volumes of aqueous vapor with the lapilli, scoria and fine ashes from Vesuvius, which, condensing into rain, produced a deluge of hot mud, filling the most intricate recesses of the Pompeian houses and producing the appearance of an aqueous deposit in the ash hills of the flanks of Vesuvius. In Herculaneum we see the same phenomena in a more remarkable manner. Here owing to a much larger accumulation of material—to subsequent overflows of lava and the superincumbent weight thus produced, with the aid of water, the ashes were consolidated into so compact a mass that some writers have even doubted whether Herculaneum had not been destroyed by an overflow of lava in the first instance. That such was not the fact is well known, and the condition of the antiquities imbedded there quite forbid the idea were no other evidence attainable.

2. *Grotto del Cane and Lake Agnano.*

The Grotto del Cane or dog grotto, has been so much cited for its stratum of carbonic acid gas covering the floor, that all geological travellers who visit Naples feel an interest in seeing it. Unfortunately, like some other grottos, its enchantment disappears on a near view. It is a little hole dug artificially into the foot of a hill facing Lake Agnano. The aperture is closed by a door, and the space within is barely sufficient for one person to stand erect. Into this narrow cell a poor little dog is very unwillingly dragged and placed in a depression of the floor, where he is soon narcotized by the carbonic acid. The earth is warm to the hand, and the volume of gas given out is very constant. Such is the world-renowned Grotto del Cane, which if it did not equal our anticipations, at least afforded us the opportunity of some merriment!

Lake Agnano, as is well known, fills the bottom of an ancient crater whose walls are still distinctly to be traced. On the shore of the lake immediately opposite the Grotto del Cane there is a constant and copious discharge of carbonic acid, and the water of the lake at that part is in great agitation from its escape. Nor is other evidence wanting of the present operation of the ancient causes which have characterized this region. At the foot of the hill on the east are numerous vents of steam and sulphur. Over some of these, vapor baths (Sudatoriæ) have been established, which are held in some repute in cases of rheuma-

tism. Digging a short distance into the hill near the ruins of the Villa of Lucullus, it is easy to perceive the presence of volcanic energy in the hot vapors accompanied with sulphur which issue copiously from the surface. The villa of Lucullus was entirely buried in lapilli and volcanic ashes, proceeding as is supposed from a vent in the immediate neighborhood; but from which vent does not appear—evidently not from the one now containing Lake Agnano, since that has not been active in the historic period.

In another cavity excavated in the hill near to the Grotto del Cane, is an abundant flow of carbonic acid, accompanied as is said by ammonia—but we did not perceive any odor of this gas nor any deposit of carbonate of ammonia or of sal-ammoniac on the walls of the place.

3. *Sulphur Lake of the Campagna, near Tivoli.*

The celebrated sulphur lake of the Campagna, near Tivoli, the Aquæ Albulæ of the ancients, still retains its interest to the geologist as the most remarkable of all the thermal sources of Italy. Whether we regard the constancy of the flow from it both of water and of gas, the area of the lake, or the important part which it and similar craters appear to have played in the formation of the travertine of the Campagna—we must admit that it is worthy of attentive consideration.

In the days of Father Kircher this lake was described as being over one mile in circuit. Now the lake is not over 500 or 600 feet in diameter, and its area is constantly diminishing. The baths of Agrippa which are now at a short distance from the shore, show the extent to which this contraction has taken place in that direction, since they were erected in the waters of the lake which were much esteemed by the ancient Romans for their hygienic effects. These baths were frequented by Augustus and enlarged by Zenobia; the latter spent her Roman servitude in Tivoli, and in allusion to this, they are still called "Bagni della Regina." At present the waters are conducted from this lake by a canal artificially cut in the travertine by Cardinal Ippolito d'Este, former governor of Tivoli, for a distance of two miles. This canal is nine feet wide and four feet deep, and there is a constant discharge of the surplus waters through it in a very rapid current—the volume of which is remarkable when we notice the small size of the source.

The strong odor of sulphuretted hydrogen announces the existence of this lake a long time before the traveller reaches it. The water was examined by Sir Humphrey Davy, who found it to contain one volume of carbonic acid, and less than $\frac{1}{2}$ volume of sulphuretted hydrogen. Tracing the canal from where it escapes the "Via Appia nova" up to the lake, a mile and a quarter, the observer is much struck with the copious escape of large volumes of gas from the whole surface of the lake, which is such as to convey the idea of ebullition. A stone cast into the water is soon followed by a very violent escape of gas, causing the whole adjoining area to boil with great energy and a loud sound of effervescence. The water is very clear, a slight milky or opaline appearance it has being due, as we thought, to the reflection of the white sides and bottom of the lake. Its temperature is 80° F., and it

has, when drank from a glass, an agreeable pungent taste of free carbonic acid—with no more of sulphuretted hydrogen than is pleasant. It is perfectly clear in the glass and effervesces briskly. The escape of gas does not appear to be confined to any particular part of the bed of the lake, but takes place equally over all its surface. The grass and reeds which grow luxuriantly at its margin are constantly encrusted with carbonate of lime from the water, and it is from this cause that the area of the lake appears to have been contracted, and not from any partial drainage which is evidently inexplicable since the level of the lake is now only a few inches below that of the adjoining and level Campagna. Breaking off a mass of grass and clods from the shore it was found that the roots of the plants were also encased, while the stone walls of the fields adjoining were wholly composed of loose blocks of travertine made up entirely of casts of the stems of growing grapes and aquatic plants. It required but casual observation of the travertine in other and distant parts of the Campagna to detect the same species of plants imbedded in every part of its mass. Blocks of travertine in the Coliseum at Rome and other ancient buildings also showed us the same evidence. A large space on the Campagna near the sulphur lakes lately fell in, owing to the cavernous and unsupported nature of the rock, and it was easy to see in the freshly fractured portions of the rock the same stems of aquatic plants, such as now grow on the margin of the water.

It is perhaps too much to infer from these casual observations so wide a deduction as that all the travertine is due to this origin from sulphur waters charged with bicarbonate of lime; but it is not going farther than is allowed by a prudent philosophy to say that travertine is now forming on the shores of Lake Solfatara from this cause.

4. *Meteorological Observatory of Mount Vesuvius.*

The Meteorological Observatory recently erected at Mount Vesuvius was projected by Prof. Melloni, so well known to all the world by his memorable researches on heat, and the most distinguished of all the Italian physicists. The King of Naples gave the enterprise his sanction, and furnished the means to construct the building. The house is of ample dimensions, standing on an artificial terrace at the summit of the hill of ashes which forms the limit of the arable region of Vesuvius, and at an elevation of about 2000 feet. The centre has three floors above the basement, and the two wings each one floor above the basement; in the rear and joining the main building is a round tower, and the roofs are conveniently arranged for meteorological purposes. All the plans were furnished by Prof. Melloni, who also superintended its erection, which by an inscription on the exterior appears to have been begun in 1841.

Unfortunately for science, the revolution of 1848 entirely arrested the farther progress of the undertaking; the house stands vacant, no instruments are provided, and worst of all, Prof. Melloni has been removed, not only from his direction in the Observatory, but also from his Professorship in the University, under the caprice of a despot who knows no law but his own will, and who has shown in this act that he was unworthy of so noble a subject.

5. *Light for Illumination obtained from the burning of Hydrogen, by M. Gillard.*

We have had an opportunity of seeing the successful application of M. Gillard's patent in the extensive silver plate works of Messrs. Christolef in Paris. It is well known that M. Gillard claims the production of a useful light and great heat from the combustion of hydrogen in contact with a coil of platinum wire—the hydrogen being produced by the decomposition of water. The apparatus employed is very simple, and consists essentially of one or more cylinders of iron arranged horizontally in a furnace similar in all respects to the usual arrangement for the production of coal gas. The retorts are charged with wood-charcoal reduced to small fragments of uniform size and heated to an intense degree. Through each of the retorts steam is conducted in a tube pierced with numerous very minute holes so disposed as to distribute the steam in an uniform and very gradual manner over the heated coal. The boiler for the production of the steam is conveniently situated in the same furnace employed for heating the retorts. Decomposition of water ensues of course, accompanied with the production of carbonic acid, (CO_2) carbonic oxyd (CO) in small quantity, of free hydrogen and a limited quantity of light carburetted hydrogen gas, (C_2H.) The mixture of these gases is conducted through a lime purifier to remove carbonic acid, and without farther washing or purification, the product is ready for use. Consisting almost wholly of hydrogen gas, the flame of its combustion is of course very feebly luminous; to obviate this difficulty, it is burned in contact with a cage or net work of platinum wire gauze surrounding an ordinary argand burner, protected by a glass chimney. This simple contrivance (so well known in the lecture-room) is perfectly successful, and the light given out from gas lamps of this construction is extremely vivid and constant.

This invention claims the following advantages in practice: 1. The gas so produced is cheaper than any other mode of artificial light, costing, as is asserted by M. Gillard and sustained by the ample experience of M. Christolef, only about $\frac{1}{16}$th the average cost of coal gas. 2. The gas has no unpleasant odor, being entirely free from the volatile hydrocarbons which are so peculiarly offensive in oil and coal gas. 3. The products of its combustion are almost solely water, so little carbonic acid resulting in the combustion that practically it may be disregarded. 4. This mode of producing gas may be applied to any existing gas works by a slight modification of the retorts, and without any essential change in other portions of the apparatus—the platinum cages being applied to the argand burners. 5. The cheapness of this mode enables us to apply it with great advantage as a fuel for cooking and for numerous purposes in the arts. For example, we saw in the establishment of M. Christolef, the soldering of silver plate accomplished in a rapid and remarkably neat manner by a powerful jet of this gas, driven by a pneumatic apparatus. Its perfect manageableness, the ease with which an intense heat is applied locally and immediately when it is wanted, coupled with advantages of employing for such a purpose so powerful a deoxydizing agent as hydrogen, render this mode

of soldering preferable to every other, and peculiarly suited for the process of autogenous soldering. 6. The nuisances resulting from the presence of large coal gas works in populous districts are entirely avoided by this mode, which is as free from objection as a steam engine. 7. The arrangements are so simple and inexpensive that every establishment where it is desired to employ light and heat, may erect its own apparatus even in the most isolated situation, all the materials employed being every where accessible.

It is understood that M. Gillard has secured his patent in the United States, and it is presumed that his method will soon be practically tested there.

We merely add that the result of M. Gillard's invention in one particular differs from the anticipation of chemists: that is, we should expect from the decomposition of water in this mode the production of carbonic oxyd CO, carbonic acid CO_2, and light carburetted hydrogen C_2 H, with a limited amount of free hydrogen. The result of his experience, however, seems to establish the statements already made, as may be seen in a report of the Commissioner of the Society for the Encouragement of Industry, &c., to whom the subject was referred.

Art. XXX.—*Extracts from the Proceedings of the Twenty-first Meeting of the British Association, held at Ipswich, July 2.**

1. *From the Address of Prof.* Airy, *the Astronomer Royal, at the opening of the Meeting.*

* * * Commencing, then, with the subject which stands first in the Reports of the Association, and on which the funds of the Association have been most generously expended and its influence very energetically employed, I remark that the progress of Astronomy in the last year has been very great. The Earl of Rosse has been much engaged in experiments on the best methods of supporting and using his large mirrors. The construction adopted some time since is still retained;—namely, a system of levers distributing their pressures uniformly over eighty-one points, each pressure being transmitted through a small ball which permits to the mirror perfect freedom of slipping in its own plane, so as to take proper bearing in the chain or hoop which supports it edgeways. To Lord Rosse's critical eye the effect even of this mounting, though greatly superior to that of any preceding, is not quite perfect. In the progress of the experiments, some singular results have been obtained as to the set which a metal so hard as Lord Rosse's composition may receive from an equal pressure of very short duration. A surface of silver, I believe, has now been successfully used for the small reflector.

With regard to the character of the discoveries in nebulæ made with this instrument I cannot briefly give any very correct idea. The most remarkable is, the discovery of new instances of spirally-arranged

* From the Athenæum of July 7 and 12, Nos. 1236, 1237.

nebulæ: but there are also some striking examples of dark holes in bright matter, dark clefts in bright rays, and resolvability of apparently nebulous matter into stars. I do not deny the importance of the last observation; but as it might be predicted beforehand that the increase in the dimensions of telescopes would lead to more extensive resolution of nebulæ, I do not hold the inference to be by any means certain that all nebulæ are resolvable. Mr. Lassell exhibited at the last meeting of the Association a plan for supporting his two-feet mirrors without flexure. This plan, slightly modified, has been adopted in use: and I am assured that the improvement in what before seemed almost perfect definition is very great.

The removal of the vexatious fiscal interferences that have been connected with the manufacture of glass, and the enterprise with which Mr. Chance as manufacturer and Mr. Simms and Mr. Ross as opticians have taken up the construction of large object-glasses, promise to lead to the most gratifying results. Already Mr. Simms has partially tested object-glasses of 13 inches aperture; and one of 16 inches is waiting not for the flint but for the crown lens. Mr. Ross, it is understood, has ground an object-glass of 2 feet aperture; but it has not been tested. The facility of procuring large object-glasses will undoubtedly lead to the construction of graduated instruments on a larger scale than before; and it is in this view that I contemplate as a matter of no small importance, the erection (this year) of the large transit-circle at the Royal Observatory at Greenwich. It is known to many members of the Association that this instrument was constructed in this town, by Messrs. Ransomes & May; and for the admirable proportions of its various parts, for the firmness of fitting of the few portions of which it is composed, and for the accuracy of the external forms of pivots, &c., it may well be considered as one of the finest specimens of engineering that has ever been produced. As an example of an excellent mechanical structure carrying a large object-glass, I think it probable that this Greenwich transit-circle may have a great influence on the construction of future instruments.

I had hoped to be able by this time to report to the Association some account of the American method of recording transits, by a puncture or dot produced by a galvanic agency whose circuit is closed by a touch of the observer's finger,—and especially on its fitness for the wants of a really active observatory; but the delays of construction have prevented me from doing so. Shortly before the last meeting of the Association, the President for the time (Dr. Robinson) transmitted to the government, on the part of the Association, a general request that a large reflecting telescope might be sent to some of the British possessions in the southern hemisphere, for the purpose of observing the southern nebulæ; and shortly after that meeting an answer was received from the Lords of the Treasury, to the effect that their Lordships entirely recognized the importance of the object, but that there appeared to be practical difficulties in the immediate execution of the design. I cannot doubt that when a more explicit plan has been formed, another representation will be accompanied with the same success which has attended every application made by the Association for aid in a carefully arranged design.

The continuation of the observations on *a* Centauri at the Cape of Good Hope has fully confirmed the result first obtained,—namely, that the parallax of that star exceeds nine-tenths of a second, or that its distance from the sun is about twenty billions of miles. So far as we have the means of judging, this star is our nearest neighbor in the sidereal spaces. The attention of foreign astronomers is still directed to the irregularities in the proper motions of stars, and the opinion seems to be gaining ground that many of them are accompanied by non-luminous companions. In our own solar system, the most remarkable discovery is that (made independently, though on different days, in America and in England) of a dusky ring interior to the well-known rings of Saturn. It now appears that it had been seen several years before; but it then attracted no attention. How such a ring is composed, and how sustained, are questions upon which perhaps the physical astronomer may long employ himself.

But the discovery for which the year will be most frequently cited is that of three additional planets, included in the same planetary space—between Mars and Jupiter—in which eleven others had been previously found. The last of these (Irene) discovered by Mr. Hind, observer in the private observatory of Mr. Bishop, forms the fourth of his list,—and makes his number the greatest that any one man has ever discovered.

Some time since, a grant was made by the British government for the perfection of the Lunar Theory and Lunar Tables on which Prof. Hansen, of Gotha, had been engaged, but whose progress was stopped by the interruption of funds in consequence of the unhappy Schleswig-Holstein war. I understand that with the aid of this grant, equally honorable to the British government and to the foreign philosopher, the work is now rapidly advancing. I have reason to believe that the theories of Uranus and Neptune are now undergoing careful revision; and I trust that one of the elements most urgently required, namely, the mass of Neptune, will be supplied from observations of Neptune's satellite made with the large telescopes to which I have alluded.

At the Edinburgh meeting, the attention of the Mathematical and Physical Section was called by M. O. Struve (there present) to the total eclipse of the sun which is to occur on the 28th day of the present month; and the General Committee appointed a committee of members of the Association to draw up suggestions for the observation of the eclipse. These suggestions have been extensively distributed both at home and abroad: and I am happy to announce one of the results. After consideration of the singular appearances observed in the eclipse of 1842, it was determined by the committee to recommend (among other things) that observing stations should be selected, if possible, in triplets: the three stations of each triplet having relation to the north boundary, the centre, and the south boundary of the shadow. The Russian government has fully adopted this suggestion; and has actually equipped six triplets, including in all eighteen stations, with observers and instruments for the observation of the eclipse. Russian officers in the Sea of Azov and the Black Sea will also observe it. Since the issue of the suggestions, the observations made last year on an eclipse visible at Honolulu in the Sandwich Islands have been received; and they make us, if possible, still more desirous that the spirit

of the suggestions should be complied with, as far as possible. There is only one subject of regret connected with this remarkable eclipse,—namely, that it will deprive us of the assistance of several astronomers who would undoubtedly have joined this meeting but for the necessity of being ready, at definite points, for the observation of the phenomena.

Among subjects related in some measure to astronomy, I may first allude to M. Foucault's experiment on the rotation of the plane of a simple pendulum's vibration; an experiment which has excited very great attention both in France and in England, as visibly proving, if proof were necessary, the rotation of the earth. It is certain that M. Foucault's theory is correct; but it is also certain that careful adjustments, or measures of defect of adjustment, are necessary to justify the deduction of any valid inference. For want of these, the experiment has sometimes failed. The Council of the Association have long regretted the very great delay which has occurred in the publication of the geodetic results of our great National Survey; and they were prepared some time since to represent strongly to the government the expediency of taking immediate steps for completing the few calculations which yet remained to be made, and for publishing the whole in a form which should be available for discussions of the figure of the earth. On communicating with the Royal Society, they learned that that body had made an urgent recommendation to the same tenor, and that in consequence, government had consented to place on the estimates a sum of money expressly for the purpose of completing and publishing the scientific portions of the survey. I have received official information that this work is now in active progress; and I cannot but remark on it as a striking instance of how much may be sometimes effected for the purposes of science by simply completing what is nearly complete. The great Swedish and Russian Arc of Meridian, from the North Cape to the Danube, is so far advanced that its completion is expected in the present year.

At the last meeting of the Association, a Committee was appointed expressly to urge on the government, what had long excited the attention of the Association, the defective state of the survey as regards Scotland. I am happy in stating that there is strong reason to hope that a large sum will in future be appropriated to the Scotch Survey.

The next subject to which the influence of the Association was energetically directed is, Terrestrial Magnetism; with which Meteorology has usually been associated. Although the active employment of several of the Colonial Magnetic and Meteorological Observatories has terminated, (those only of Toronto, Hobartown, Cape of Good Hope, Madras and Bombay being retained, and only in partial activity,) the work connected with them has not yet ceased. Much has yet to be done in the printing and discussion of the observations:—a work going on under the care of Col. Sabine. In tacit association with the representative of the government, the agents of the Association are employed at the Kew Observatory, under the superintendence of Mr. Ronalds, in devising or examining new instruments. The Daguerrotype method of self-registration (which is perhaps liable to this objection, that the original records are destroyed) has been extended to the vertical-force instrument. Apparatus has been arranged for the graduation of original

thermometers—a subject to which the attention of M. Regnault and Mr. Sheepshanks had been advantageously directed. And, with the assistance of a portion of the sum placed by the Government at the disposal of the Royal Society (to which I shall hereafter refer), it is hoped by the officers of the Association that the Kew Observatory will be made really efficient for the testing of new instruments. Dr. Robinson's very instructive account of his new anemometer has lately been received: this instrument, however, has not yet been used in many places. Among the immediate deductions from magnetic observations, I may specially mention Col. Sabine's remarks on the periodical laws discoverable in disturbances apparently of the most irregular kind, and M. Kämtz's corrections of the Gaussian constants.

Among the more distant results, there is nothing comparable to the experiments into the magnetic properties of oxygen, and especially into the variation of its power, made by Faraday and Becquerel,—and the application of these results to the explanation of the phenomena, in almost all their varied forms, of so-called terrestrial magnetism. It is to the former of these philosophers that this great step in the explanation of obscure natural phenomena by inference from delicate experiments, is mainly or entirely due. Much, of course, remains to be done, before we can pronounce accurately how far this principle enables us to account, without any reference to any other cause, for the regular changes, as well as for the capricious disturbances, in ordinary magnetism. I ought not to omit stating that such general explanation had long ago been suggested in a very remarkable paper by Mr. Christie; but the experiments actually applying to the magnetic properties of oxygen were unknown, and perhaps impossible, at that time. In the science of abstract magnetism, the distinction between paramagnetic and diamagnetic substances has been thoroughly worked out by Mr. Faraday, and is now received as one of the most remarkable laws of nature. In the related subject of Galvanism, although much of detailed law has been established by the labors of the same great man and of others, it is difficult to fix upon any new law of general character. Experiments made in America seem to establish that the velocity of the galvanic current in iron wires of a certain size does not exceed fifteen or eighteen thousand miles per second: a much greater speed, however, is inferred by M. Fizeau, from the same experiments. The first part of an elaborate mathematical theory of Magnetism, by Prof. Thomson, has been published.

In Meteorology, some striking facts have been collected and arranged by Col. Sykes in regard to India, by Messrs. Schlagentweit in regard to the Alps, and by M. Plantamour in the comparison of observations at Geneva and the Great St. Bernard; and some very unexpected facts have been extracted by M. Arago from the observations on a balloon ascent at Paris. The systematic collection of observations of luminous meteors, in Reports by Prof. Powell, printed in the volumes of the Association for the last two years, can scarcely fail to lead to some discovery of the origin and nature of those mysterious bodies. An extensive series of meteorological observations had been made at the Ordnance Survey Office at Mountjoy, near Dublin, and the Association some years since recommended to the government the early printing

of those observations. I have the gratification of stating that considerable progress has now been made in preparing them for the press.

At the last meeting of the Association, a project was laid before the General Committee, by M. Kupffer, for the formation of a Meteorological Confederation, to be extended over the whole of Europe. A very extensive organization, covering almost the whole Russian Empire, has already been created. The Council to whom the project was referred, after very careful consideration, deemed it inexpedient to join in the proposed Confederation. They were deterred by various practical difficulties, of which some may perhaps always exist, while others are felt with unusual force at the present time. It was with extreme unwillingness that the Council adopted this resolution, and with the full hope that at some future time a confederation similar to that proposed by M. Kupffer may be firmly established.

Under the auspices of the Board of Ordnance, the officers of the corps of Royal Engineers are making arrangements for the establishment of a uniform system of meteorological observations, of a simple kind, at the principal engineers' stations in every part of the earth. If with these could be combined occasional trustworthy observations at sea, we should probably have the most complete system of Terrestrial Meteorology that we can hope to obtain.

Among the systematic observations of less ostentatious character, I cannot omit referring to the daily report of the state of the wind at 9 o'clock every morning, which is supplied by the superintendents of railway stations, over a great portion of the British isles, and printed in the *Daily News* newspaper.

A new Meteorological Society has been formed, which (I believe) is at least in this respect, superior to those which have preceded it—that the instruments used by the various amateur members are strictly comparable: great attention having been given to the adjustments of the instruments, by the Secretary, Mr. Glaisher.

In Optics, two or three investigations of rather important character have, since the last meeting of the Association, attracted public attention. Experimental measures of the velocity of light in air and in water, made by MM. Foucault, Fizeau and Brequet, with apparatus nearly similar to that employed long ago for analogous purposes by Mr. Wheatstone, appear to leave no doubt that the velocity in water is less than that in air,—a most important, and indeed critical, result in regard to theories of light. A remarkable investigation by Prof. Stokes, when compared with experiment, seems to establish that the vibrations constituting polarized light are, as for other reasons was supposed by Fresnel, perpendicular to what is usually called the plane of polarization. Some optical theories which admitted formerly of very imperfect mathematical treatment have been brought under the dominion of analysis by Prof. Stokes's powerful methods of investigation. A curious series of experiments on diffraction has been published by Lord Brougham; but they have at present no bearing on theory, as the theoretical calculations with which they must be confronted appear to be too difficult or too complicated for the present state of pure mathematics. The experiments of Jamin regarding the reflection of polarized light under peculiar circumstances appear to give support to the

theoretical calculations of Cauchy, founded on a molecular hypothesis applied to the undulatory theory. And lastly, some curious experiments by Mason, Jamin, Prevostaye, and Desains, appear to show more fully, what had partially been shown by Prof. Forbes, that radiant heat admits of polarization in all respects similar to that of light. * * *

2. *On Diamagnetism and Magne-Crystallic Action;* by Dr. J. TYNDALL.

One of the most important inquiries which at the present day occupy the attention of the student of physical science, is the relation which subsists between magnetism and diamagnetism. Are the laws which govern both forces identical? Will the mathematical expression of the attraction in the one case be converted into that of the repulsion in the other case, by a change of sign from positive to negative? To this question Plücker replies "No." His experiments have led him to the conclusion, that when the power of a magnet which operates upon a body composed of magnetic and diamagnetic constituents is increased, the diamagnetism of the compound mass increases in a much quicker ratio than the magnetism; that in consequence of this an indifferent body is a physical impossibility; for a body in which the respective forces might be exactly equal and apposite when excited by a magnet of a certain strength would, upon lowering the power of the magnet below this standard, be attracted,—and by increasing the power of the magnet beyond this standard, be repelled.

During a previous investigation, the author of the present memoir had repeated opportunities of observing phenomena exactly similar to some of those which form the premises of Plücker's conclusion; and a close study of the subject convinced him that to account for these phenomena the hypothesis of two conflicting forces in the same compound mass, the one or the other of which predominates according as the power of the magnet is increased or diminished, was by no means necessary. To fit himself for the investigation of this question, he commenced an inquiry last November into electro-magnetic attractions; one of the results of this inquiry was, that a sphere of soft iron separated from the end of a straight electro-magnet by a small fixed distance, was attracted by the latter with a force exactly proportional to the square of the exciting current. Now, this attraction is in each case the product of two factors, one of which expresses the magnetism of the magnet, and the other the magnetism of the ball; and it is easy to see, that while the attraction increases as the square of the current, the magnetism of the ball increases in the simple ratio of the current itself. Our way to a comparison of magnetic attraction and diamagnetic repulsion is now clear. We know the law according to which the magnetism of the iron ball increases, and we have only to inquire whether the diamagnetism of the bismuth ball follows the same law. The apparatus used in the former case proved, however, to be totally unfit for the measurement of diamagnetic force,—the feebleness of the latter rendered a much more delicate mode of measurement necessary. The torsion balance was the instrument finally resorted to by the author. A loop of paper was attached to one end of a fine silver wire, and in the loop rested a little beam of light wood. At the ends of the

beam, which was six inches long, two spoon-shaped hollows were worked out, in each of which a ball of the substance to be experimented with might be placed. Two cones of soft iron, surrounded by helices of copper wire, were placed at right angles to the beam when horizontally suspended, the one cone facing the ball at one end, and the other cone facing the ball at the other end. The silver wire was carried upward through a tube three feet in length, and was connected at the top with a torsion head. When the cones were excited, by sending an electric current through the surrounding helices the balls were repelled. The index of the torsion head was then gently turned against the repulsion until the balls were brought within $\frac{1}{12}$th of an inch of the ends of the respective cones. The torsion necessary to effect this is evidently the expression of the repulsive force exerted at this particular distance. The strength of the exciting current was measured by a galvanometer of tangents, and it was regulated by means of a rheostat. The cones were excited by currents which varied from 10° to 57°, and the corresponding repulsions were determined. Spheres of the following diamagnetic substances were used:—1. Bismuth of commerce; 2. Chemically pure bismuth obtained by dissolving the material of commerce in nitric acid, precipitating it with distilled water, washing the precipitate for six days successively, and reducing it by means of black flux; 3. Sulphur of commerce; 4. Spheres from a crystal of native sulphur obtained in Sicily; 5. Calcareous spar from Clitheroe [?]; 6. Calcareous spar from Andreasberg, in the Hartz mountains, Germany. In all these cases the diamagnetism of the spheres followed precisely the same law as the magnetism of the sphere of soft iron:—it was exactly proportional to the exciting current.

These results cannot be reconciled with the statement that diamagnetism increases with the increasing power of the magnet in a much quicker ratio than magnetism. The experiments of Plücker might be accounted for in many ways, but such explanations, being necessarily conjectural, may be omitted here. It is known that crystalline bodies suspended between poles of a magnet exhibit phenomena which are absent in the case of amorphous bodies. A certain line through the crystal will take up a certain determinate position; and if this line be forcibly moved away from this position, when the force is removed it will return to it. Thus, a crystal of pure carbonate of lime suspended by a silk fibre between the poles with its optic axis horizontal, will always turn until the optic axis is perpendicular to the line joining the poles, in which position it will come to rest. This fact was discovered by Plücker, who referred it to the operation of a new force which was entirely independent of the magnetism or diamagnetism of the mass of the crystal. In an investigation conducted by the author in companionship with Prof. Knoblauch, of Marburg, this hypothesis of a new force is rejected; and it is there shown that the position of the optic axis, so far from being independent of the magnetism and diamagnetism of the mass, is entirely changed if a magnetic constituent be substituted for a diamagnetic. Thus, for instance, carbonate of iron differs from carbonate of lime only in the fact that in the former case an atom of iron is substituted for an atom of calcium. The crystalline form in both cases is identical, the optic axis of carbonate of iron sets

nevertheless from pole to pole with an energy far surpassing that with which the optic axis of carbonate of lime sets perpendicular to the line joining the poles. But why is it that one direction in the crystal takes up a particular position? The torsion balance gives a prompt answer to this question. A sphere of calcareous spar was placed upon each of the spoon-shaped hollows of the beam, the direction of the optic axis through each sphere being carefully marked. The spheres were first placed so that the optic axes were parallel to the axes of the soft-iron cones,—and secondly, perpendicular to the same. The repulsion in the former case was to the repulsion in the latter in the ratio of 53 to 48. If a bismuth crystal be suspended between two poles, the plane of most eminent cleavage will always set perpendicular to the line joining the poles, that is, equatorial. A cube formed from this crystal was placed on each end of the little beam; first, so that the planes of principal cleavage were parallel to the axes of the cones; and secondly, perpendicular to them. The repulsion in the former case was to the repulsion in the latter, in the ratio of 53 to 38. The diamagnetic mass in both these cases is repelled with a greater force in one direction than in any other direction. When the crystal is suspended between two poles, the line which marks the direction of maximum repulsion recedes as far as possible from the poles, and hence sets equatorial.

A result the exact antithesis of the above was observed with magnetic crystals. A cube of sulphate of iron was attracted in one direction by a force of 43, and in another direction by a force of 36·3. A sphere of carbonate of iron was attracted in the direction of the optic axis by a force of 43, and in a direction perpendicular thereto by a force of 30·5. When these crystals are suspended between two poles, these lines of chief attraction approach the poles, and finally set axial. Thus we see that the peculiar phenomena exhibited by crystals in the magnetic field are to be referred to a modification of magnetism or diamagnetism brought about by the peculiar structure of the crystal. Let us endeavor to penetrate this mystery of structure. Our next inquiry is—what direction is that which is chosen by the respective forces for the manifestation of their greatest energy? To this question the author imagines that a full and intelligible reply is returned by experiment. If the arrangement of the component particles of any body be such as to present different degrees of proximity in different directions, then the line of closest proximity (other circumstances being equal) will be that of strongest attraction in magnetic bodies, and of strongest repulsion in diamagnetic bodies. The torsion balance furnishes us with the means of submitting this conclusion to a direct test. A quantity of bismuth was ground to dust in an agate mortar, gum-water was added, and the mass was kneaded into a stiff paste. This was placed between two glasses and pressed together. From the mass when dried two cubes were taken, the line of compression being perpendicular to two of the faces of each cube and parallel to the other four. Suspended by a silk fibre in the magnetic field, upon closing the circuit the line of compression turned strongly into the equatorial position, exactly as the plane of most eminent cleavage in the case of the crystal. The cubes were placed one upon each end of the torsion balance, first with the line of compression parallel to the axis of the cones, and secondly per-

pendicular thereto; the repulsion in the former case was to the repulsion in the latter in the ratio of 53 : 30. A greater differential action was thus exhibited in the case of the model than in the case of the crystal. A pair of cubes constructed in the same manner from powdered carbonate of iron, exhibited an analagous predominance of attraction in the line of compression.

Against this mode of experiment an objection was urged, during the meeting of the British Association at Edinburgh last year, by Prof. Wm. Thomson, of Glasgow. "You have," he said, "reduced the mass to powder, but you have not thereby destroyed the crystalline form; your powder is a collection of smaller crystals,—and the pressing of the mass together gives rise to a predominence of axes in a certain direction, so that the repulsion and attraction of the line of compression, which you refer to closeness of aggregation, is after all a product of crystalline action. Besides, we know that compressed isinglass exhibits the same optical phenomena as crystals, and you are unable to prove that the action is not due to a *quasi* crystalline structure induced in the gum by compression." The following experiment will set this point at rest. It will not only show the influence of compression apart from the mere arrangement of the axes or from the influence of the gum, for none will be used; but it will also demonstrate the total nullity of this presumed axial force where opposed to the influence of compression. To this experiment I was conducted by the following accident. The investigation was conducted in Berlin, and the great electro-magnet of the University was beside me at the time. Some notion of the power of this magnet may be gathered from the fact, that the copper helices alone which surrounded the iron pillars which composed the magnet, weighed 243 pounds. On the top of the pillars two movable masses of soft iron were placed, each weighing about 25 pounds, and between these the substance to be examined was suspended. Before I had thoroughly made the acquaintance of the instrument, I hung a fine cube of bismuth crystal between these movable poles; on closing the circuit the planes of most eminent cleavage receded to the equator. Scarcely, however, was this attained when I observed the poles moving towards each other, and before I could break the circuit, they had rushed together and clenched their iron jaws upon the crystal. The latter was reduced by the pressure to about three-fourths of its primitive thickness, and it immediately occurred to me that if the theory of proximity were true it ought to tell here. The pressure brought the particles of the crystal in the line of compression more closely together, and hence a modification, if not an entire reversion, of the former action might be anticipated. Having liberated the crystal, I boiled it in hydrochloric acid, so as to remove any impurity it might have contracted by contact with the iron. It was again suspended between the poles, and completely verified the foregoing anticipation. The line of compression, that is, the magnecrystallic axis of the crystal, which formerly set from pole to pole, set now equatorial. The experiment was then repeated with a common vice; various pieces of bismuth protected by plates of copper were placed within its jaws, and there pressed to the thickness of a shilling. The plates thus obtained when suspended from their edges in the magnetic field, exhibited one

unvarying result:—the line of compression stood always equatorial, and it was a matter of perfect indifference whether this line was the magnecrystallic axis or not. In these cases no gum was used, and not only was a predominance of axes present, but they all worked together; they were further assisted by the great mechanical advantage offered by such plates to diamagnetic repulsion; the line of compression nevertheless triumphed over all and determined the position of the crystal.

The author concludes his paper as follows: "Whoever denies the influence of proximity will have to answer the following questions:—How is it possible that a greater differential action can be exhibited by a cube of bismuth dough, than by the crystal itself? What is it which causes the magnecrystallic axis to forsake its usual position, and to set equatorial when the crystal is compressed in the direction of that axis? He must further assume a crystalline structure on the part of wax, flour, shale, and the pith of fresh rolls; for in all these substances the line of compression determines the position of the mass in the magnetic field."

At the conclusion of the paper, Prof. Faraday rose, and spoke at some length on the valuable contribution to science which had been brought before them by Dr. Tyndall. It afforded him great gratification that there was one at least among us who had followed up this important subject so perseveringly. The beautiful laws established by Dr. Tyndall proved the identity of magnetism and diamagnetism in one important particular,—a result which he always anticipated; and if the crystalline action could be explained by what might be called the gross mechanical experiments brought before them, the discovery was one of the utmost consequence. It gave him pleasure to be able to propose a question to one who had worked so long at the foundations of this matter. Many philosophers had affirmed that it was possible to convert attraction into repulsion, and *vice versâ*, by merely varying the magnetic power: this was contrary to his own experience, and he wished to ask Dr. Tyndall whether he had ever met a case of the kind.—Dr. Tyndall stated in reply that he had diligently sought for such a case, but had never succeeded in finding it.

Prof. Faraday felt prepared to admit that some of Dr. Tyndall's results seemed to promise an explanation of Plücker's perplexing results and conclusions; but for his own part he was anxious to keep his mind free from bias, to get well-established facts, and to free them as much as possible from all circumstances which could mark, or disguise, or mislead in the interpretation of them,—and such being his fixed determination and settled habit, he was rather at a loss to remember to what portion of his publications on the subject Dr. Tyndall referred when he supposed him to have considered the facts now brought forward as improbable.

3. *Report of the Kew Magnetographs;* by Col. Sabine.

The author said that at the request of the Council he was about to give the Section a brief account of the experimental trial now making at the Kew Observatory of Mr. Ronald's instruments for the self-registry of the variations of terrestrial magnetism by means of photography.

These instruments had been described at former meetings: but it was deemed advisable to subject them to a practical trial to test their efficiency as a means of recording the magnetic phenomena in any part of the world where science might require them to be better known. Before, however, it could be known in what degree they might be useful either as auxiliary or as superseding altogether the method of observation previously in use, it was necessary that three instruments should be provided,—one for the variations of declination and two for those of the horizontal and vertical components of the forces. The limited funds at the disposal of the Association for the purposes of the Kew Observatory barely enabled them to complete two of these instruments between the years 1846 and 1850; and the third must have yet been waited for had not the President and Council of the Royal Society, seeing the importance of the object, appropriated a portion of the sum placed at their disposal by government to this purpose. The three instruments being now completed, Mr. Ronalds proposed to the Council that a six months' trial should be made of the working of these instruments precisely as they would be in an observatory, and that every item of expense incurred in that practical trial should be carefully noted and faithfully reported. The Council of the Royal Society having approved of this trial, a grant was made from the donation fund of 100*l*. The six months' trial commenced in April last, and when it shall be completed a full report will be made to the Council of the Royal Society. In the mean time it was thought that a brief report of the progress so far made would be acceptable.

In Mr. Ronald's instruments the magnetic variations are recorded either on silvered plates or on prepared paper. The silvered plates have the advantage of greater sensibility, and in consequence require a less time of exposure to the light,—so that movements of a more rapid character or more transient duration may be recorded by them; also, they produce more sharply defined traces; they are free from the defects arising from inequalities of surface, and the stretching and shrinking of the paper by being wetted and dried. The paper on the contrary, has the advantage that the original tracings and records of the variations can be preserved,—a matter impossible with the plates, except in some very rare and interesting cases. In coming to a just conclusion in this comparative estimate of the merits of each method, the practical object to be attained should be kept in view. No doubt a mere inspection of the actual tracings as shown either on the plates or the paper possesses an interest both to the uninstructed and to those more familiar with the phenomena; and amidst the great variety of them some may have light thrown on them by a close inspection and consideration of the trace itself. But as in astronomy the great advance of the science has followed the combination of measuring apparatus with optical power,—so in terrestrial magnetism the various periodical and other causes which in their joint action produce the variations, require that the traces of them should undergo tabulation as an indispensable preliminary to their practical application. In Mr. Ronald's plan the tracings when taken on the silvered plates are tabulated with tolerable rapidity, and are then copied by hand with a graver's tool on sheets of transparent gelatine paper,—an operation requiring about a

quarter of an hour to copy the twenty-four hours work of the instrument. Both sides of the trace being marked, this can be done after a little practice with very considerable accuracy. The copies thus made are arranged in a journal and preserved. The original plate, except in rare cases, is then cleared off for new work. The gelatine paper is transparent, durable, and bears handling so well that impressions can be freely taken on paper with printers' ink and a small press; which on days of unusual disturbances can be sent by post to other observatories. The measuring and taking the means and tabulating the tracings are a far more serious operation as far as time is concerned; but under the able management of Mr. Welch, to whom Mr. Ronalds has intrusted this department of the experimental trial, this can be all accomplished for the twenty-four hours' work in about three-quarters of an hour,—and thus the great advantage of producing a continuous record is obtained. The plates as used at Kew are twelve inches long, and every twelve hours are reversed, thus giving a second tracing on each plate. The breadth there used is three inches, which is found to be ample. But in parts of the globe where great disturbances prevail and where at the same time great precision is required in the variations of small amount, a larger field than three inches may be desirable and may be given. It has been found by the concurrent experience of several that the tracings on the plates can be read off with full confidence to the 500th of an inch. This gives in the three-inch plate, 1,500 distinctly recognizable points. Taking the declinometer as an easily understood example, a single division of the scale is made equal to six seconds: the range of the scale will therefore extend to $6 \times 1{,}500 = 9{,}000$ seconds, or $2^\circ\ 30'$.

Great stability and freedom from shaking of Mr. Ronalds's apparatus is obtained by binding together all parts which have reference to each other by marble or metal, and only using wood for outside casing. Another great advantage is, the constancy of the zero line, which is insured by mechanical contrivance. The zero line has thus a permanent magnetic value which remains unchanged as well from day to day as at all times of the same day. The time of the exposure to the light by which each part of the tracing is at present taken is one and a half minutes. It is, however, probable that by improvements in photographic preparations, the trace may hereafter be taken by exposure of much less duration; also that the length of the magnets, now twelve and fifteen inches, may be greatly reduced. Both these improvements appear to be required if we desire that the trace should individualize perturbations succeeding each other with great rapidity.

The Astronomer Royal said that, while he admitted that at Kew the photographic method of registering these or similar observations was first introduced successfully, and that the methods there used were essentially the same as those of Mr. Brook, which had been adopted at the Royal Observatory, Greenwich, he could not help thinking that there was one important distinction. In Mr. Brook's method, a sheet of photographic paper wrapped on a cylinder received and recorded the working of the instrument; and these original records, carefully dated, were kept. Where silver plates were used it was of course impossible to preserve the original records; after the tracings were

transferred by hand to the gelatine paper the silver plates had to be cleaned off, otherwise it is obvious they would soon multiply to a number too expensive and cumbrous to be used. Now, he had strong doubts that any person could transfer by hand all the minute fluctuations of the instrument; he did not now speak of the great magnetic storms, the indications of which were constant and universal, but he alluded to those sudden, slight, but now important agitations which the instrument seemed to undergo after working on each side of its mean position with great steadiness. And yet, from the recent discovery of Prof. Faraday as to the varying relations of oxygen to magnetism by alterations of the temperature, it became highly probable that these same slight waverings of the magnetometer would be found to have an interest attached to them hitherto altogether unsuspected.

4. *On our Ignorance of the general course of the Tides;* by Dr. Whewell.

In 1833 Dr. Whewell published in the *Philosophical Transactions* an essay towards a first approximation to a map of co-tidal lines; in which he attempted, from the data then accessible, to draw lines expressing the course of the tide wave all over the ocean. So far as the coasts are concerned, this mode of expressing the course of tides is still held to be the best; but our materials, which were scanty at the former period, are very incomplete even yet, with the exception of the coasts of Europe and the east coast of North America, the east coast of Australia, and the east coast of New Zealand. In order to trace the course of the tides on any coast, we ought to know the points of divergence and of convergence of the tidal wave. We do not know these points on the west coast of Africa, or on the east coast of South America; and consequently we do not know the course of the tides of the Atlantic, nor do we know the relation of the tides of the Atlantic islands, (the Ferroes, Azores, Bermudas, Cape Verde Islands, &c.,) to the tides of the coasts. It was urged that the course of the tides in this and other oceans could not come to be known except by an expedition, consisting of one or two small vessels, which should have for its primary and governing object the obtaining a connected knowledge of the tides of the coasts of the Atlantic, in the first place, and of those of other oceans afterwards.

The Astronomer Royal said that the inquiries to which Dr. Whewell had now directed their attention had an object definite, intelligible, and most important, whether we considered it practically in its bearing on commerce and our navy, or as an object of pure science, in furnishing the data requisite for advancing our knowledge on this interesting yet intricate branch. In such a case he found it to be always a most important matter to make a beginning, however humble, and from his own experience he could assure Dr. Whewell that he felt convinced if a proper application were made to the government to observe the tides carefully in the manner pointed out by Dr. Whewell in some limited locality,—say in the Atlantic Ocean,—such an application would meet with the attention which it so well deserved, and which he at all times found the government cheerfully to bestow on such matters. He had not the least objection, should such an application be deemed proper

by the Committee of Recommendations, to join Dr. Whewell or any Committee which should be named in pressing such an object on the attention of Her Majesty's government.

Capt. FitzRoy, R.N., said that as Dr. Whewell had done him the honor of alluding to his exertions and opinions on this interesting, and to every sailor important, branch of science, he would beg leave to make a few remarks. In the first place, he must bear his testimony to the accuracy of the statement of the learned gentleman who had brought the subject before them as to the extreme intricacy and puzzling character of the general phenomena, and our deplorable ignorance of extensive fields of research in it. It was known to most of those whom he addressed, that Sir John Herschel in his very delightful work estimated the average height of the rise of the tide over the whole surface of the earth to be five feet; and from all the attention he could bestow on the subject and the best estimate he could form, guided by long continued and very widely extended actual observations of the tides, he believed this to be a very correct opinion. And yet most who heard him were aware how widely in several localities this average was departed from. Several localities could be pointed out where the total rise of the tide was to be spoken of as inches; while in other, and frequently not very distant, places, the rise was six, seven, eight, or more fathoms.

Capt. FitzRoy then stated, that along the entire western coast of South America the tides could scarcely be said to be earlier or later at one place than at another,—as for hundreds of miles, indeed nearly as far as Panama, they might be said to occur at the same time, though they only rose four or five feet. At the Straits of Magellan they were very remarkable; on the west side they rose but a few feet, say four or five, but on the eastern side they rose to the enormous height of seven or eight fathoms, and this within a few miles the one place of the other. He considered this to be accounted for thus.—On the western side they partook of the general character of the tides of the Pacific along the coast,—but on the east, the great tide from the Atlantic setting in through the Straits and meeting the tide coming from the west, the waters became heaped up to the extraordinary height he had stated. He then proceeded to mention several other peculiarities and anomalies of the tides in the Great Pacific Ocean:—and said that a general review of them had led him to throw out the conjecture alluded to by Dr. Whewell, that in this great basin the tides seemed to be at one time urged forward by the luminary as it passed along over them towards the west, and then afterwards seemed to surge back again towards the east; and in this motion to an fro the waters of this great basin might be conceived as a whole to partake; while yet the motion of no one part need move more than a very few feet from its place.

5. *Observations on Atomic Volumes and Atomic Weights, with considerations on the probability that certain bodies now considered as elementary may be decomposed;* by Prof. DUMAS.

Prof. Dumas alluded to the solubility of some substances and the insolubility of others, giving many instances of the difference of this quality in regard to solution in water, sulphuric and strong acids, and

referred to Berthollet's views and experiments on this subject. The measure or volume of bodies he thought might be represented with as much facility as the weight: thus, for example, magnesia and sulphuric acid may have their volumes numerically expressed before and after combination, and also graphically by lines. Magnesia with sulphuric acid showed a certain degree of condensation, lime a greater condensation, and barytes the greatest condensation; and these he could represent and reason on as well by lines of different lengths as by figures or by words. The degree of condensation (however expressed) had also relation to the quality or degree of solubility. Thus, sulphate of magnesia was very soluble, sulphate of lime but little soluble, and the greatly condensed sulphate of baryta was insoluble. He then pursued the analogy with the chlorids, comparing the chlorid of sodium with the extreme case of the chlorid of silver.

After graphically expressing the solubility of bases with sulphuric acid by lines, he proceeded to show that the relative volumes of the elements chlorine, bromine, and iodine could be perfectly represented by lines equal in length. Prof. Dumas said that when a number of metals are represented by lines, at first they seem in confusion, and it would appear like an impossibility to arrange them in a system of lines to permit their relations to appear; but when considered in relation to the substitution of one property for another, or of the substitution of one substance for another in groups, then their arrangement became easy. And here we may remark, that Prof. Dumas had not previously prepared diagrams or tables, but covered a large black board with lines, figures, and formulæ, to follow his train of reasoning,—and symbols, volumes, and names were rapidly produced and as rapidly effaced to illustrate the Professor's views of the laws of the substitution of one body for another in a compound. Prof. Dumas gave many examples of groups of other bodies, such as the alkalies, earths, &c., arranged in the order of their affinities. He called attention in the Triad groups, to the intermediate body having most of its qualities intermediate with the properties of the extremes, and also that the atomic or combining number was also of the middle term, exactly half of the extremes added together; thus, sulphur 16, selenium 40, and tellurium 64. Half of the extremes give 40, the number for the middle term. Chlorine 35, bromine 80, and iodine 125. Or the alkalies, lithia, soda, and potassa, or earths, lime, strontia, and baryta, afford, with many others, examples of this coincidence; hence the suggestion, that in a series of bodies, if the extremes were known by some law, intermediate bodies might be discovered; and in the spirit of these remarks, if bodies are to be transformed or decomposed into others, the suggestion of suspicion is thrown upon the possibility of the intermediate body being composed of the extremes of the series, and transmutable changes thus hoped for.

Prof. Dumas then showed that in the metals similar properties are found to those of non-metallic bodies; alluding to the possibility that metals that were similar in their relations, and which may be substituted one for the other in certain compounds, might also be found *transmutable*, the one into the other.

He then took up the inorganic bodies where substitutions took place which he stated much resembled the metals. After discussing groups

in triads, Prof. Dumas alluded to the ideas of the ancients of the transmutation of metals and their desire to change lead into silver and mercury into gold; but these metals do not appear to have the requisite similar relations to render these changes possible. He then passed to the changes of other bodies,—such as the transmutation of diamonds into black lead under the voltaic arc.

After elaborate reasoning and offering many analogies from the stores of chemical analysis, Prof. Dumas expressed the idea that the law of the substitution of one body for another in groups of compounds might lead to the transformation of one group into another at will; and we should endeavor to devise means to divide the molecules of one body of one of these groups into two parts, and also of a third body, and then unite them, and probably the intermediate body might be the result. In this way, if bodies of similar properties and often associated together were transmutable, one into the other, then by changes, portions of one might often, if not always, be associated with the other. Thus, in nature when chlorine occurred, iodine and bromine might also be found, and always would be if they were transmutable the one into the other. Cobalt is thus mysteriously associated with nickel, iron with manganese, sulphur with selenium, &c. In the arts during operations when certain radicles were produced, analogous ones were found constantly to be associated. In the distillation of brandy, oil of wine is always an associated result.

Dr. Faraday expressed his hope that Prof. Dumas was setting chemists in the right path; and although conversationally acquainted with the subject, yet he had been by no means prepared for the multitude of analogies pointed out.

Mr. Grove spoke of the importance of the view; as, by knowing the extreme compounds, it might serve as a guide in experiments and as a check to the results. He adverted to the allotropic condition of substances when their principal characters were changed, but their chemical qualities were unaltered; thus, carbon in the state of a diamond had a change of property so complete that it had one of the properties of metals given or transferred to it by its conducting power for electricity under these conditions, and its other forms were states resistant to electric passage. He thought this fact of certain bodies having two sets of physical properties with greatly differing character might, with this law of the substitution of one set of chemical qualities for another in a compound group, give the hope of the great realization of some of the ideas embodied in the views of the possible transformation of one body at the will so as to possess the properties of others.

Prof. Williamson, Dr. Anderson, and Dr. Gladstone remarked on these analogies,—and referred to the groups of bodies of similar characters, but whose history was difficult or inexplicable. Thus, the metals of the platina group of bodies, the red states of phosphorus and of sulphur, the carrying of certain of these properties into the sulphurets of phosphorus, and the unsatisfactory history of bodies like the phosphates, might be rendered clear in future researches by the ideas resulting from numerous examples of the triad groups alluded to by Prof. Dumas.

6. *On a Copying Electric Telegraph;* by Mr. F. C. Bakewell.

In the method adopted for transmitting copies of writing, the letters to be transmitted are written on tin-foil with varnish, so as to present a conducting and a non-conducting surface. The foil is placed on the cylinder of the transmitting instrument, and a metal style in connection with a voltaic battery presses on the surface of the cylinder as it revolves. By this means the electric current is continually broken when the style is resting on the varnish, and as the style is made to traverse by an endless screw from one end of the cylinder to the other, it passes necessarily over all the lines of the writing, and about eight times over each line.

The receiving instrument is similar to the transmitting one, and on the cylinder of that instrument, paper moistened with a solution of prussiate of potash in diluted muriatic acid is placed; the metal style on that instrument being a piece of steel wire. When the electric current from the positive pole of the voltaic battery passes through the steel point to the paper, a blue mark is made by the production of Prussian blue,—and when the cylinder is in motion, the effect is to draw a series of spiral lines on the paper; but as the lines are broken whenever the varnish writing on the transmitting cylinder interposes, the forms of the letters are transferred from one instrument to the other,—the writing appearing of a pale color on a ground of blue lines drawn closely together. To produce this effect, it is requisite that both instruments should rotate exactly together, and this synchronous movement is attained by means of an electro-magnet,—one instrument being made to regulate the other by retarding its motion at regular intervals.

The regulation of the instrument is also facilitated by a guide-line, consisting of a strip of paper placed at right angles to the writing, by which means the person in charge of the receiving instrument can ascertain how much the speeds of the two instruments differ, and by the addition or subtraction of weight can bring the gaps formed by the strip of paper to fall exactly under each other,—which indicates that the two cylinders are revolving at the same rate. It was stated, in answer to questions by members present, that two hundred letters per minute might be copied by the instruments exhibited, and that five hundred in a minute are attainable. To illustrate the facility which this means of telegraphic communication affords for transmitting secret messages, an apparently blank piece of paper was produced, on which a message had been impressed invisibly before the meeting of the Section, and by brushing it over with a solution of prussiate of potash the writing became instantly legible.

(*To be continued.*)

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Crystalline form of the Rhombohedral Metals*, (Berichte der Berl. Akad.)—Prof. G. Rose, in continuation of his previous investigations, has examined an artificial crystal of Tellurium obtained by Mitscherlich. The form was a regular six-sided prism terminated by rhombohedral faces. The angle of the rhombohedron at the terminal edges was found to be 71° 51′. This rhombohedron is therefore a secondary to the primary rhombohedron. Prof. Rose also reckons among the rhombohedral metals the *Tetradymite* (Tellurwismuth) from Schemnitz. It affords the two rhombohedrons 81° 2′ and 66° 40′ according to Haidinger, the former being that, parallel to whose faces, composition occurs and twins are formed. Prof. Rose is therefore inclined to consider this mineral as a joint crystallization of the three constituents, bismuth, tellurium and sulphur, rather than a chemical compound. *Zinc* is also included among the rhombohedral metals. Nöggerath has observed it in hexagonal prisms and this is confirmed by Rose. The latter found for the inclination of the base on three adjacent planes replacing the basal edges respectively 110° 35′—110° 40′, 110° 31′—110° 42′, and 111° 45′—111° 50′. The discrepancy is considered not more than was to be expected from the character of the crystal, and the prism is taken to be regular hexagonal. On breaking the mass, a perfect cleavage parallel to the base of the prism was often observed, besides another cleavage less perfect. The observation of Laurent that zinc crystallizes in rhombic prisms is supposed to be an error. The statement of Nickles that it also crystallizes in monometric or tesseral forms, is not improbable since zinc has many relations to the tesseral metals. The fact shows that zinc is dimorphous.

2. *On the Equivalent of Magnesium;* by MM. R. F. Marchand and Th. Scheerer, (Journ. f. prakt. Chem., vol. l, heft 8; Phil. Mag. Feb., 1851, p. 170.)—The uncertainty which still exists as to the true chemical equivalent of magnesium, notwithstanding the numerous experiments on the subject, induced the authors to undertake fresh researches to settle the question.

The process which these chemists adopted to determine this point, consists in ascertaining the quantity of carbonic acid contained in a given quantity of native carbonate of magnesia. The mineral which principally served for these experiments is the magnesite of Frankenstein, of which very pure specimens were obtained. The numerous experiments which the authors performed show that the choice of the mineral is in nowise indifferent. When magnesite contains considerable quantities of silica, carbonate of iron, alumina, and especially water, which it is almost impossible to expel by drying without simultaneously disengaging small quantities of carbonic acid, it is unfit for the purpose of analysis.

The magnesite of Frankenstein contains only 0·05 per cent. of foreign matter, of which an account is taken in the calculations. A certain quantity of this mineral, well powdered, was introduced into a glass

tube, and was placed in a stove, the temperature of which could be raised at pleasure. By heating this stove to 300° C., and at the same time passing a current of dry air deprived of carbonic acid, all the water which the magnesite contained was removed with certainty; but at the same time carbonic acid was disengaged, which it was requisite to collect and estimate. For this purpose the current of air was directed, at its exit from the tube, into two vials containing perfectly transparent barytes water. The carbonate of barytes collected at the conclusion of the drying was estimated in the state of sulphate; and the quantity of carbonic acid, which the weight of the sulphate represented, was added to that obtained by the following operation.

The residue which remained in the tube, after being weighed, was calcined at a strong red heat; the loss of weight indicated almost the whole of the carbonic acid contained in the mineral; the calcined residue still contained a trace of it. To determine its amount, the authors dissolved the residue in hydrochloric acid, and passed over the hot solution a current of air, which removed some traces of carbonic acid, and which were deposited in perfectly clear barytes water. Thus the whole quantity of carbonic acid which a given weight of the magnesite contained, consisted of—1, the portion removed by drying at 300°; 2, that expelled by calcination; 3, the small portion which remained in the calcined residue.

All these experiments were performed and considered with sufficient care, and gave satisfactory results. The last eleven determinations, which the authors deem most worthy of confidence, gave a mean of 250·34 as the equivalent of magnesium.

As all the errors which may be committed in such delicate analyses tend rather to lower the real number, MM. Marchand and Scheerer are of opinion, that, neglecting the insignificant fraction of thirty-four hundredths, the round number 250 may be adopted as the equivalent of magnesium, that of oxygen being 100, or 20, taking the equivalent of hydrogen as unity. According to this statement, 100 parts of magnesia consist of 60 magnesium and 40 oxygen; and 100 parts of carbonate of magnesia are constituted of 47·619 carbonic acid and 52·381 of magnesia.

The researches of MM. Marchand and Scheerer place magnesium among the number of simple substances, the equivalents of which are multiples of that of hydrogen by a whole number.

3. *New Metal, Donarium*, (Pogg. Ann., vol. lxxxii, April, 1851.)—This new metal Donarium was obtained by Dr. Bergemann, while experimenting on the Wöhlerite and Eukolite of Brevig, Norway. A mineral substance was separated, which has since been called *Orangite*, which is essentially a silicate of Donarium, of the formula $Do^2 O^3, Si O^3 + 2HO$, and affording on analysis—

Si	Do, O	Ca Ċ	Fe	Mg & Mn	K & little Na	H
17·695	71·247	4·042	0·310	0·214	0·303	6·900=100·711

The metal was obtained from the oxyd by means of potassium; it formed a heavy coal-black powder, which, when dry and rubbed in a mortar acquired a metallic lustre. It burns when thrown into the flame of a lamp with a reddish light, and forms a red oxyd. Hydrochloric acid, hot or cold, has no action on the metal; and nitric acid only when

heated. Nitro-muriatic acid changes it rapidly to a red oxyd, and a small portion is held in solution. With sulphuric acid it readily forms a sulphate. The atomic weight deduced from the composition of this sulphate, is 997·4, or near that of bromine. 100 parts of the oxyd contain 13·072 of oxygen. The oxyd on charcoal alone is unaltered, and with the usual tests it gives no characteristic reaction. The bead with soda contains particles of undissolved oxyd, distinguishable with a lens by their red color. With borax or salt of phosphorus the bead is yellowish, becoming colorless on cooling.

4. *On Aridium, a new metal;* by M. Ullgren, (Oefv. of Kongl. Vet.-Akad. Förh., 1850, No. 3, p. 55; J. f. pr. Chem., lii, 443.)—This new metal is found in chromic iron, and is closely allied to iron and chromium, whence the name from *Ἄρης*, *Mars*, the alchemistic name of iron.

5. *Bismuth.*—R. Schneider has determined anew the equivalent of bismuth by oxydizing pure bismuth by means of nitric acid and removing the acid by heat. He obtained as a mean of eight good determinations, bismuth 89·655, oxygen 10·345. This gives for the equivalent of bismuth, 2599·95 or 2600.

6. *Alkalies.*—An article by Ebelmen on the separation of the alkalies from magnesia and on the analysis of minerals containing the alkalies, is contained in the Ann. de Ch. et de Phys., 3d ser., vol. xxx, p. 324, Nov., 1850.

II. Geology.

1. *Discovery of Fossil Fish in the Coal Formation of New Brunswick;* by Dr. C. T. Jackson.—Dr. Jackson in a letter to one of the editors, dated Boston, June 20th, announces the discovery of perfect specimens of fossil fish in the coal mine of Albert county, N. B., on the 5th of May last, and larger numbers on the 27th of May, and of Lepidodendra on the 6th of June. The following is cited from his letter:—"I returned to Boston on the 12th, with numerous fossil fishes of Hillsboro, N. B., the miners having followed up my discoveries of May last, and found even better specimens than I had myself discovered on my first visit.

You may feel interested in knowing that I have made out some of the genera and found new species of fossil fishes and that the Paleoniscus occurs abundantly associated with aquatic plants; also that a Lepidodendron, near if not exactly identical with the *L. gracile*, Br., is found with the fishes and with scattered fish scales in the same piece of the shale. Broad flat leaves like those of palms occur also in the fish shales of the coal mine and a curious blistered leaf is extremely abundant in all parts of the fish strata. These I at last traced to a stem. They appear to be new species and remind me of our aquatic floating plant, the bladder-wort of our ponds.

The occurrence of immense quantities of well preserved coprolites of fishes verifies the idea of Agassiz, that the heterocercal tailed fishes swam close to the bottom; for otherwise the form of such materials could not be preserved; for they were entire in the mud which ultimately enveloped them. There are herbivorous fishes associated with those that ate them and the excrements of some tell the tale that some

of the fishes were cannibals! Some of the coprolites I have seen connected with the anus of the fish appearing as if extruded by compression of the fish. Some of the fish appear to have been dead and partially putrid when they were enclosed in the strata, others evidently struggled hard against adverse fortune, erected their fins strongly to guard themselves from some imagined swallower, while others wiggled and squirmed in vain to free themselves from the tenaceous mud which embalmed them in their last struggle. In fact these fishes are literally embalmed and not petrified, the bitumen which so richly charges the marly or soft clay slate or shale preserving in the most delicate manner every scale, fin, and the minutest markings; the scales retain their silvery hue slightly tinted yellowish brown by the bituminous matter."

2. *Immense Coal bed.*—Mr. J. Dill has communicated to the Family Visitor a brief account of a remarkable deposit of mineral coal at Straitsville, Perry county, Ohio, which, if true, exceeds anything of the kind before discovered. He writes:—

"Reports of an immense structure of coal in the vicinity of this place, have long been circulated in Central Ohio. I first heard of it in the winter of 1848–9; it was then reported to be about ninety feet thick. Further examinations ascertained the thickness of the uncovered part, in the face of a deep ravine at 112 feet. A few days since a gentleman of high standing informed me, that an acquaintance of his, with some others, had stripped the upper surface of the bed and bored through the coal stratum to ascertain its thickness, and found it to be 138 feet."

Mr. J. W. Foster adds, in a letter to the editors, as follows:—

"Although this extent is at variance with all our previous knowledge of carboniferous deposits, yet I have no doubt that, in the main, it is true. I was recently within a day's ride of the locality, but regret that I was unable to devote the requisite time to its examination. I conversed with several intelligent persons who had seen the deposit and all concurred in representing it as one of unparalled thickness. It is exposed for several miles in the banks and along the bed of a small stream—one of the tributaries of the Hocking river. Like most of the coals of Ohio, it is highly bituminous and is more or less impregnated with iron pyrites which for manufacturing purposes, impairs its value. The deposit instead of being one bed, may be regarded as a repetition of beds; for, at intervals of a few feet, we meet with thin seams of shale, forming natural divisions. Altogether, it may be regarded as the most wonderful deposit yet brought to light."

3. *On Fossil Fish in the Coal rocks of Ohio;* by J. W. Foster, (Communicated for this Journal in a letter dated Brimfield, June 23.)—While at Zanesville, recently, I discovered a locality in the carboniferous series, rich in the remains of fishes. Associated with them were several species of molluscs and corals, and even the delicate fronds of the Neuropteris. I have never before observed a locality where the forms of animal and vegetable life were so confusedly mingled. I have also succeeded in procuring beautifully preserved teeth from the limestone of Cambridge, belonging to this series—the existence of which I had known for several years.

Within the last few years, it has been proved that the occurrence of the remains of fishes in many of the western groups of rocks, is by no means rare. In the Clinton group at the base of the Upper Silurian, as developed in the Lake Superior district, we have detected markings similar to those in the same group in New York, made by some vertebrated animal, probably a fish. Mr. Joseph Sullivant has observed the remains of fishes consisting of teeth, scales and fins in numerous instances in the Cliff limestone of Columbus, (Upper Silurian,) and Prof. Agassiz, in a recent visit to the quarries, was enabled to collect numerous specimens, and we may hope, ere long, to receive exact information as to the character of these ancient species.

Dr. Norwood found a well-preserved jaw in the same group, at Madison, Ia. Messrs. Whittlesey and Brainard of Cleveland have brought to light well-preserved specimens from the Devonian, or perhaps subcarboniferous system of Northern Ohio; while at Zanesville and Cambridge, we have indisputable evidence of their occurrence in the true carboniferous.

4. *Sulphate and Carbonate of Copper of Bristol, Conn.*—On page 222 we failed to state that the copper ore contains both sulphuric and carbonic acids, but the fact of their chemical combination remains in doubt.

III. Zoology.

1. *On the Classification of the Crustacea Grapsoidea;* by James D. Dana.—The Grapsoidea, in the system here explained, correspond to the Cyclometopa of Edwards, excepting that we separate the Telphusa, group and place it with the Cancroidea.*

A few of the species have the fourth joint of the outer maxillipeds articulated by the inner angle with the third, as in the Cancroidea: of these we make the family Gonoplacidæ, or the Grapsoidea Cancridica.

In all the other species, this articulation is remote from the inner angle, being either near the middle of the apical margin or at the outer angle. The near universality of this character among the Grapsoidea is proof of its importance, and sustains us in removing from along side of the Gonoplacidæ the Macrophthalmi.

The Macrophthalmus and Ocypod groups are closely related, and with Doto make our *second* family the Macrophthalmidæ,—characterized by the great length of the eye-peduncles, the very narrow front, and the 2nd joint of the male abdomen narrower than the corresponding part of the sternum.

The Grapsus family—the third has the same limits as in the system of Milne Edwards. The form is subquadrate, with the lateral margin anteriorly more or less acute; the front broad; the eyes of moderate length or short; the second joint of the male abdomen usually not narrower than the corresponding part of the sternum. We give more importance than has hitherto been done to the fact of the outer maxillipeds having an oblique piliferous crest on the surface or not; and we make this characteristic the basis of a subdivision of the Grapsidæ (exclusive of the Plagusinæ) into the subfamilies *Grapsinæ* and *Sesarminæ*,

* This volume, p. 130.

the former characterized by the absence of this crest. A survey of the groups will at once show, we believe, that we follow natural lines in this subdivision. The *Plagusinæ* are distinguished by longitudinal sinuses in the front of the carapax for the inner antennæ.

The family GECARCINIDÆ—the fourth—is the same in limits as the "Gecarciniens" of Edwards,—the species are remarkable for their thick obese forms, high rounded front and antero-lateral margin, and for having the second joint of the male abdomen but slightly narrower than the corresponding part of the sternum.

The family PINNOTHERIDÆ—the fifth—differs from the "Pinnotheriens" of Edwards in the removal of the genus *Doto*, closely related to Ocypod, and also the genus *Myctiris*, an aberrant form between Pinnothera, Doto and Helœcius, but very peculiar in being narrow anteriorly, and having no distinct orbits for the retraction of the eyes. The genus *Myctiris* constitutes the last or sixth family MYCTIRIDÆ. In the Pinnotheridæ, the male abdomen is much narrower than the sternum behind, which character separates them from the Gecarcinidæ.

We do not believe in a properly lineal order in classification; yet the succession we have given to the families is a natural succession, as nearly as can be made. The *first*, Gonoplacidæ, link the Grapsoidea with the Cancroidea, and the genus Eucrate is very near Eriphia and Panopæus in form. The *second*, Macrophthalmidæ, is closely allied to the first, so much so that Marophthalmus and Gonoplax have been arranged in the same group. The *third*, Grapsidæ, are again very near the Macrophthalmidæ, and the genus Helice is almost as correctly placed with one as the other. Thence the transition is as gradual also to the *fourth* or Gecarcinidæ, and from the fourth to the *fifth* or Pinnotheridæ, and from the fifth to the *sixth* or Myctiridæ. Still, there are other relations of somewhat less prominence which this order does not exhibit. That of *Elamena* to Inachus has long been recognized.

The Gonoplacidæ are placed in the Cancer group by DeHaan, who neglected the important distinction based on the male verges. The other genera, exclusive of Pinnothera and the species related, he divides into two groups, the *Ocypus* and *Grapsus* groups, the former having the fourth joint of the outer maxillipeds articulated with the outer angle of the third, and the latter, articulated with the middle of the apical margin;—a distinction difficult to carry out and dividing natural groups, as the Gecarcinidæ, Grapsidæ, &c. His genera of the OCYPUS group, are, Doto, Scopimera, Myctiris, Gelasimus, Macrophthalmus, Cleistostoma, Cardisoma, Chasmagnathus, Helice, Uca, Ocypoda, Acanthopus (a division of Plagusia); those of the GRAPSUS group, are, Gecarcinus, Philyra (division of Plagusia), Plagusia (another division), Grapsus, Trichopus, Eriocheir, Pachysoma, Goniopsis, Platynotus, Brachynotus, Nautilograpsus, Cyclograpsus, and in his "Decas Septima," published in 1849, he unites with the group, Pinnotheres and Hymenosoma.

We add a few words on the genera of GRAPSIDÆ. Both De Haan* and Randall† have divided the Grapsus of authors into two genera, according to the *short* or *oblong* form of the third joint of the outer max-

* Faun. Japon., p. 33, 1833.

† Jour. Acad. Nat. Sci., Philad., viii, 124, 126.

illipeds. The former are De Haan's *Grapsi*, and Randall's *Pachygrapsi;* the latter De Haan's *Goniopsea* and Randall's *Grapsi*. But the length of this joint, as we have shown in many other cases, is a characteristic of small importance, and such a basis for subdivision is therefore wrong. There are two natural groups; one with arcuate sides, like *G. pictus*, and the other with straight sides like *G. cruentatus* and *G. messor;* and in each, this joint may be short or oblong. *G. variegatus*, like *G. pictus*, has the joint oblong; yet a species every way similar and hitherto referred to the *variegatus* has the same joint not longer than broad.* We hence reject this subdivision and adopt two others, viz: *Grapsus*, having arcuate sides, and *Goniograpsus*, having straight sides. The latter forms the transition to *Sesarma* and *G. cruentatus* is like the *Sesarmæ* in habit.

The genus *Cyclograpsus* of Edwards is characterized by its author as having a piliferous crest on the outer maxillipeds, though exceptions are admitted. Subsequently, M'Leay made his genus *Gnathochasmus* on the same type. Some recent authors have taken M'Leay's name for these typical species and restricted *Cyclograpsus* to the exceptions. We find no authority in the rules laid down by the British Association, or in the nature of the case, for thus perverting Cyclograpsus from its true type as first established, and we therefore make Gnathochasmus a synonym of it, and adopt a new name for the species without the piliferous crest. This we believe is due to M. Edwards.

The following is a synopsis of the Families, Subfamilies and Genera of Grapsoidea:—

CRUSTACEA GRAPSOIDEA.

1. Articulus maxillipedis externi 4tus angulo 3tii interno articulatus.

Fam. I. GONOPLACIDÆ.

Carapax transversus. Frons quartâ parte latitudinis carapacis longior, paulo deflexus, lamellatus. Antennæ internæ transversæ. Articulus abdominis *maris* 2dus sterno contiguo angustior.

G. 1. Eucrate, *De Haan.*†—Carapax antice arcuatus, parce declivis, *Panopæo* formâ antennisque affinis. Appendices *maris* sexuales e sterno ortæ abdomineque tectæ. Pedes *maris* antici breves, crassi. Oculi breves. Abdomen *maris* 5-articulatum, versus basin sterno contiguo vix angustius.

G. 2. Curtonotus, *De Haan.*‡—Carapax antice arcuatus, parce declivis, margine antero-laterali rotundato. Appendices *maris* sexuales e basi pedum ortæ, in canaliculo sterni ductæ, deinde abdomine tectæ. Oculi breves. Pedes *maris* antici prælongi.

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* The species referred to is one from Valparaiso. The *G. variegatus*, according to its description by Edwards, and the figure by Guerin, has the joint quite oblong. The Valparaiso species, which we name the *Grapsus planifrons*, has this joint no longer than broad.

† Crust. Faun. Japon., p. 36. *Geryon*, Kröyer, Tidskrift, i, (1837,) p. 15, pl. 1.

‡ De Haan, Crust. Faun. Japon., p. 20. *Pseudorhombila*, Edwards, Crust. ii, 58.

G. 3. Gonoplax, *Leach.*—Carapax latus, trapezoidalis, antice elongatè transversus, angulis anticis acutis. Appendicibus *maris* sexualibus *Curtonoto* affinis. Oculi longi. Pedes *maris* antici prælongi.

2. Articulus maxillipedis externi 4tus angulo 3tii interno non articulatus.

Fam. II. MACROPHTHALMIDÆ.

Oculi tertiâ parte latitudinis carapacis non breviores. Carapax subquadratus, sæpissimè transversus, antice latissimus, angulis anticis acutis, lateribus non arcuatis. Antennæ internæ sive transversæ sive longitudinales. Articulus abdominis *maris* 2dus sterno contiguo angustior. Articulus maxillipedis 3tius costâ obliquâ piliferâ nunquam ornatus.

1. MACROPHTHALMINÆ.—Antennæ internæ transversæ, sub fronte insitæ. Antennæ externæ basi frontem appressæ. Articulus maxillipedis externi 4tus apertus.

G. 1. Cleistostoma, *DeH.**—Carapax subquadratus, paulo transversus. Frons quartâ parte latitudinis carapacis vix brevior. Oculi longiusculi. Pedes antici *maris feminæve* breves. Articulus maxillipedis externi 3tius 2do vix minor, quadratus.

G. 2. Macrophthalmus, *Latr.*—Carapax latus, transversim rectangulatus. Frons angustissimus. Oculi longissimi. Articulus maxillipedis externi 3tius 2do multo minor.

2. OCYPODINÆ.—Antennæ internæ longitudinales, juxta frontem utrinque insitæ. Antennæ externæ fronte paulum remotæ. Articulus maxillipedis externi 4tus apertus, 3tius 2do minor.

1. *Articulus maxillipedis externi 2dus 3tio valde major.*

G. 1. Gelasimus, *Latr.*—Oculi graciles, corneâ parvulâ, parce oblongâ. Pedes *maris* antici portentosè inæqui. Manus minor debilis, digitis sæpissimè instar cochlearis excavatis aut spatulatis.

G. 2. Helœcius, *Dana.*†—Oculis habituque *Gelasimo* affinis. Pedes antici subæqui. Abdomen versus basin sterno contiguo vix angustius. Maxillipedes externi sulco lineari fere longitudinali superficie notati.

G. 3. Ocypoda, *Fabr.*—Oculi crassi, corneâ longâ, fere ad pedunculi basin productâ. Pedes *maris* antici inæqui, minoris digitis acuminatis. Abdomen basi angustum. Carapax transversus.

2. *Articulus maxillipedis externi 2dus 3tio parce major, non oblongus.*

G. 4. Scopimera,‡ *DeH.*—Corpus globoso-cubicum. Pedes *maris* antici subæqui, non crassi. Habitu *Gelasimo* affinis.

3. DOTINÆ.—Articuli maxillipedis externi 4tus et sequentes 3tio celati.

Genus Doto, *DeH.*§—Corpus subquadratum.

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* Crust. Faun. Japon., p. 26.—From κλειστος, *shut*, and στομα, *mouth*—not *Cleistotoma.*

† Includes *Gelasimus cordiformis.*

‡ Crust. Faun. Japon., p. 24.

§ Crust. Faun. Japon., p. 24.

Fam. III. GRAPSIDÆ.

Oculi tertiâ parte latitudinis carapacis breviores. Carapax subquadratus, sæpius depressus, lateribus aut rectis aut arcuatis. Antennæ internæ transversæ. Articulus abdominis *maris* 2dus sterno postico sæpius vix angustior. Articulus maxillipedis externi 3tius sive inornatus sive costâ obliquâ ornatus. Palatum lineâ elevatâ viæ efferentis limite instructum.

1. GRAPSINÆ.—Antennæ internæ fronte tectæ. Articulus maxillipedis externi 3tius costâ obliquâ in 2dum productâ non notatus.

1. *Maxillipedes externi vix hiantes.*

G 1. Pseudograpsus, *Edw.*—Articulus maxillipedis externi 3tius orbiculato-cordatus, aut subquadratus, 2do brevior. Frons dimidio latitudinis carapacis vix brevior. Carapax lateribus arcuatus.

G. 2. Eriocheir, *De H.**—Articulus maxillipedis externi 3tius uti in *Pseudograpso*. Frons dimidio latitudinis carapacis multo brevior. Carapax subpolygonatus.

G. 3. Platynotus, *De H.*†—Articulus maxillipedis externi 3tius 2do longior, margine postico valde obliquo.

G. 4. Trichopus, *De H.*‡—Articulus maxillipedis externi 3tius latior quam longior, extus dilatatus. Pedum articuli 5tus 6tusque posticorum compressi denseque ciliati.

2. *Maxillipedes externi rhomboidicè hiantes.*

G. 5. Grapsus, *Lamk.*—Carapax transversim lineolatus, lateribus plus minusve arcuatis. Frons dimidio latitudinis carapacis brevior. Antennæ externæ juxta frontis latera oblique exsertæ. Tarsi spinulis armati.

G. 6. Goniograpsus, *Dana.*§—Carapax transversim lineolatus. lateribus rectis, postice sæpe convergentibus. Frons dimidio latitudinis carapacis longior. Antennæ externæ sub frontis margine sæpius exsertæ. Tarsi spinulis armati.

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* Faun. Japon., p. 32, 59.—The genus *Utica* of White, (Ann. Mag. Nat. Hist., xx, 206, and Crust. Voy. Samarang, 52, pl. 13, fig. 6,) appears to have the essential characteristics of Eriocheir, and like Eriocheir differs but little from Pseudograpsus. The front is narrow, the form subpolygonal, and it lives like E. Japonicus, in fresh-water. The bushy hair on the hand of the Japan species is not necessarily a generic character. The name Eriocheir is therefore unfortunate, and it would be better for the science to substitute the name given by White.

The *E. penicillatus* of De Haan, (p. 60, pl. 11, f. 6,) appears to be a true Pseudograpsus.

† Faun. Jap., p. 34.

Brachynotus is the name of another genus by De Haan based on a Mediterranean species described by Risso, Hist. Nat. de l'Eur. Merid., v, 13. The male abdomen is but 4-jointed, the female 7-jointed; 2d and 3d joints of the outer maxillipeds of equal length, and the 3d truncate at either extremity.

‡ Faun. Jap., p. 32.—*Varuna* of Edwards, Crust. ii, 94.

§ In part, *Goniopsis* of De Haan, F. Jap., p. 33, and *Pachygrapsus* of Randall, J. Acad. Nat. Sci., Philad., viii, 126.

G. 7. Planes, *Leach.**—Carapax non lineolatus, lævis, fere quadratus, parce oblongus. Frons rectus. Articulus maxillipedis externi 3tius latior quam longior, cordatus. Tarsi spinulis armati.

G. 8. Hemigrapsus, *Dana.*†—Carapax non lineolatus, fere lævis, lateribus plus minusve arcuatis. Frons rectus aut rectiusculus, antennis internis tranversis. Articulus maxillipedis externi 3tius fere orbiculato-cordatus. Tarsi inermes.

G. 9. Cyrtograpsus, *Dana.*—Carapax gibbosus, subhexagonus non lineolatus. Frons sursum sinuosus, antennis internis obliquis, inplicis frontis insitis. Articulus maxillipedis externi 3tius suborbiculato-cordatus. Tarsi inermes.

2. SESARMINÆ.—Antennæ internæ fronte tectæ. Articulus maxillipedis externi 3tius costâ obliquâ in 2dum productâ notatus.

1. *Articulus maxillipedis externi 3tius apice rotundatus.*

G. 1. Sesarma, *Say.*‡—Carapax quadratus, sæpe partim lineolatus, lateribus rectis, fronte rectè prærupto. Abdomen *maris* versus basin sterno contiguo vix angustius. Tarsi sæpe armati.

G. 2. Sarmatium, *Dana.*—Carapax subquadratus, lateribus arcuatis, fronte curvatim declivi. Abdomen *maris* versus basin sterno contiguo vix angustius. Tarsi inermes.

2. *Articulus maxillipedis externi 3tius apice truncatus et sæpe excavatus.*

G. 3. Cyclograpsus, *Edw.*§—Carapax lævis, medio planus, ad margines anteriores declivis, lateribus arcuatis, integris. Abdomen *maris* versus basin sterno contiguo vix angustius.

G. 4. Chasmagnathus, *DeH.*‖—Carapax convexus, subquadratus, lateribus arcuatis et antice emarginatis, fronte curvatim declivi. Oculi breves. Abdomen *maris* versus basin sterno contiguo parce angustius.

G. 5. Helice, *DeH.*¶—Carapax quadratus, lateribus parallelis, rectis. Oculi longiusculi. Abdomen *maris* versus basin sterno contiguo multo angustius.

3. PLAGUSINÆ. Antennæ internæ sinubus frontis longitudinalibus apertæ.

G. 1. Acanthopus, *De H.***—Corpus valde depressum. Articulus maxillipedis externi 3tius oblongus, parvus, apice 2di multo angustior. Ramus maxillipedis 1mi internus apice angustus et not transversus.

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* Mss. Mus. Brit.; the genus is recognized in Bowdich's "Madeira and Porto Santo," p. 151; and more lately in Bell's Brit. Crust., p. 133.—*Nautilograpsus* of Edwards, Crust. ii, 89.

† *Grapsus* (subgenus) of De Haan, F. Jap., p. 31; *Cyclograpsus*, in part, of Edwards, Crust. ii, 77.

‡ Jour. Acad. Nat. Sci., i, 76, 1817. *Pachysoma*, of De Haan, Faun. Japon., p. 33.

§ Crust. ii, 77.—Gnathochasmus, of M'Leay, Smith's Illust. Zool. S. Africa, and Cat. Crust. Brit. Mus. by A. White, 1847, 40.

‖ Faun. Japon., p. 27.

¶ Faun. Japon., p. 28.

** Faun. Japon., p. 29. Corresponds to *Plagusia clavimana.*

G. 2. Plagusia, *Latr.**—Corpus minus depressum, crassius. Articulus maxillipedis externi 3tius apice 2di vix angustius, raro longior quam latior. Ramus maxillipedis 1mi internus apice transversus.

Fam. IV. GECARCINIDÆ.

Oculi breves. Carapax obesus, paulo transversus, antice latus, curvatim declivis, lateribus arcuatis poneque oculos large rotundatis, vix dentatis. Antennæ internæ transversæ. Articulus abdominis maris 2dus sterno contiguo vix angustior. Articulus maxillipedis externi 3tius costâ obliquâ piliferâ non ornatus. Palatum lineâ elevatâ viæ efferentis limite non instructum.

1. UCAINÆ. Articulus maxillipedis externi 4tus apertus.

1. *Maxillipedes externi non hiantes.*

G. 1. Uca, *Leach.*—Articulus maxillipedis externi 4tus angulo 3tii externo insitus.

G. 4. Gecarcinucus, *Edw.*†—Articulus maxillipedis externi 4tus marginis medio apicalis 3tii insitus.

2. *Maxillipedes externi rhomboidicè hiantes.*

G. 3. Cardisoma, *Latr.*—Articulus maxillipedis externi 4tus apice 3tii externo insitus.

G. 4. Gecarcoidea, *Edw.*—Articulus maxillipedis externi 4tus marginis medio excavato apicalis 3tii insitus.

2. GECARCININÆ. Articuli maxillipedis externi 4tus et sequentes 3tio celatus.

G. 1. Gecarcinus.

Fam. V. PINNOTHERIDÆ.

Oculi breves, orbitis insiti, raro non retractiles. Carapax sive obesus sive depressus, raro paulo oblongus et interdum parce rostratus, lateribus valde rotundatis. Antennæ internæ aut transversæ aut obliquæ. Abdomen *maris* angustum, versus basin sterno contiguo valde angustius. [Species omnes parvæ.]

2. PINNOTHERINÆ. Articulus maxillipedis externi 2dus parvulus aut obsoletus. Corpus sive obesum sive depressum.

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* *Plagusia* and *Philyra* of De Haan, Faun. Japon., p. 31; the latter genus in his system including *Plagusia depressa* of authors, and the former the *P. squamosa*. The distinction between his two genera consists in this; the palpus of the outer maxillipeds in *Plagusia* has a flagellum, and that of *Philyra*, none. The name *Philyra* belongs to another genus of earlier date, instituted by Leach; moreover, the resemblance between the species of these groups is so close in other characters, that we hardly consider the distinction important as a generic character.

† Jacquemont's Voy. dans l' Inde, plate 1.

1. *Oculi approximati. Fossæ antennales conjunctæ.*

a. Pedes 8 postici sat graciles, subæqui.

G. 1. Pinnothera, *Latr.*—Corpus obesum. Carapax superficie integerrimus, nunquam areolatus. Oculi normales.

G. 2. Fabia, *Dana.*—Corpus obesum. Carapax superficie anticâ pone orbitas suturâ divisus. Oculi normales.

G. 3. Xenophthalmus, *White.**—Corpus obesum, fronte incisionibus duabus profundis oculos gerentibus instructo.

G. 4. Xanthasia, *White.*†—Corpus depressum, supra fere planum margineque elevato utrinque instructum, fronte paulo producto. Oculi normales.

b. Pedes 4ti longiores et multo validiores.

G. 5. Pinnixa, *White.*‡—Corpus portentosè transversum.

2. *Oculi sat remoti. Fossæ antennales septo latiusculo sejunctæ. Articulus maxillipedis externi 2dus fere dimidii 3tii longitudine.*

G. 6. Pinnotherelia, *Lucas.*§—Pedes 8 postici sat graciles, subæqui. Corpus suborbiculare.

2. HYMENICINÆ. Corpus sæpius parce rostratum, depressum. Articulus maxillipedis externi 2dus dimidio 3tii major.

G. 1. Hymenosoma, *Leach.*—Carapax suborbiculatus, angulo extra-orbitali acuto. Frons angustissimus, non lobatus, oculis valde approximatis.

G. 2. Halicarcinus, *White.*‖—Carapax suborbiculatus, angulo extra-orbitali nullo. Frons tridentatus, antennis internis inter dentes se porrigentibus, oculis remotioribus. Articulus maxillipedis externi 3tius 2do paulo major.

G. 3. Hymenicus, *Dana.*¶—Carapax suborbiculatus, angulo extra-orbitali nullo. Frons productus, simplex aut lobatus, antennarum basin celans, oculis remotioribus. Articulus maxillipedis externi 3tius 2do paulo major. Pedes gracillimi.

G. 4. Elamena, *Edw.*—Carapax subtriangulatus, paulo oblongus, paulo rostratus, fronte antennas internas celante. Articulus maxillipedis externi 3tius 2do minor.

Fam. VI. MYCTIRIDÆ.

Corpus obesum. Carapax fronte perangustus, orbitis carens; antennæ internæ longitudinales.

Genus Myctiris, *Latr.*

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* White, Ann. Mag. Nat. Hist., xviii, 178, and Voy. of Samarang, p. 63. The genus *Fabia* forms a transition from Pinnothera to Xenophthalmus; it includes the *P. chilensis.*

† Ann. Mag. Nat. Hist., xviii, 176.

‡ Ann. Mag. Nat. Hist., xviii, 177. Includes Say's *Pinn. cylindricum*, Jour. Ac. Nat. Sci., Philad., i, 452.

§ Crust. of D'Orbigny's S. Amer., p. 24. The genus forms a transition to the Gecarcinidæ.

‖ Ann. Mag. Nat. Hist., xviii, 178.

¶ The genus *Hymenosoma* belongs to the Cape of Good Hope, *Halicarcinus* to the extremity of S. America, and *Hymenicus* to New Zealand.

2. *Note on the genera Hexapus and Arges of De Haan;* by J. D. DANA. —The genus *Hexapus* of De Haan, in his first publication of its characters, (in Decade I. and II. of the Fauna Japonica, pp. 5 and 35,) is arranged near Pinnothera, which it resembles in its short obese form and small size. But in his last Decade, published in 1849, which contains his final remarks on classification, at p. xiv, the genus is referred to the vicinity of Pilumnus.—The outer maxillipeds are as in Pilumnus. The genus is peculiar in the 5th pair of legs being obsolete. The species is the *H. sexpes*, (Jap., p. 63 and pl. 11, f. 6, *Cancer sexpes* of Fabricius, Ent. Syst., Suppl., p. 344, f. 37.)

The genus *Arges* of De Haan, (Faun. Japon., p. 21,) includes only a fossil species. It is Cancroid in its outer maxillipeds and near Pilumnus and also Menippe. The abdomen in both sexes is 7-jointed; in the male oblong-trigonal, in the female ovate. The lateral margins of the carapax are parallel and entire, and the general form is much like that of *Cyclograpsus Audouinii* and the allied. Distance between the eyes one-fifth the breadth of the thorax.—Sp. *A. parallelus* (F. Jap., p. 52, and pl. 5, f. 4) from Japan.

3. *On the Resuscitation of Frozen Fish;* by Prof. O. P. HUBBARD. —With a previous notice on this very interesting subject in the Am. Journal, vol. x, p. 132, I made a request that correspondents would communicate other examples of the kind. In reply I have received the following letter from Prof. J. P. Kirtland, M.D., which details a remarkable instance of resuscitation.

To Prof. O. P. HUBBARD, *Dear Sir*:—In accordance with your request, as expressed in the foregoing article, I will communicate in detail some facts in regard to the resuscitation of frozen fish.

To persons familiar with the locality, it is known that a brook or small rivulet arises from springs, among the granite hills between Durham and Haddam in the state of Connecticut and ultimately discharges itself into Connecticut river a little south of the city of Middletown. In its passage among the high bluffs, it in one instance winds its way through a marsh of several acres in extent, immediately below which, a high dam is thrown across it from bluff to bluff. This raises the water some eight or ten feet over the marsh and forms a reservoir for the purpose of supplying a series of mills on the stream below, during the droughts of summer. At the approach of winter the artificial outlet is usually closed by a gate and the water collects till it is wanted during the following season.

In this pond or reservoir had accumulated large numbers of the common eel and as they were usually restrained from descending the stream at the approach of winter, as is their habit when left to themselves, many of them had attained a large size.

The autumn and winter of 1819–20 or of the succeeding year (which, I am not certain,) was distinguished for the scanty supplies of rain and the low stages of water in the streams in that section of country. Winter set in with heavy and repeated falls of snow, the drought still continuing. A heavy body of ice formed on this pond and upon it rested eighteen inches or more of snow. About mid-winter the mill owners drew off all the remaining water and the ice rested on the soft mud at the bottom. The immense pressure seemed to incommode the eels in their winter quarters and they commenced collecting in the

small center channel which constituted the original stream and descended through the gateway of the dam in search of a more favorable retreat.

Below the dam the brook descends from one level to another among the rocks, forming little pools one or two feet in depth and a few feet wide, in which large quantities of fallen leaves had accumulated. Beneath these the eels retreated. The weather had been cold for many weeks and the surface of the pools was thickly congealed and frequently involved the leaves and the eels.

On an extreme cold morning my brother-in-law, Caleb Atwater, now of Atwater in Ohio, a Mr. Hall of Durham and myself visited the place, prepared for a fishing exploit—not however in accordance with the nice directions of that prince of fishermen, Isaac Walton, but armed with an axe, shovels and baskets.

We were not the first to visit the ground. The foxes had ranged over them and the remains of many an half-devoured eel showed that Reynard is a skillful disciple of honest Isaac though perhaps he never read Isaac's interesting book.

Our operations commenced by cutting large portions of the ice from the surface of the pools—then we found very little difficulty in crowding the eels with the wet leaves into the basket by means of our shovels. A dozen or more were frequently taken at a time. The severity of the weather rendered them rather dull though they were able to swim with some activity.

As soon as they were secured in the basket they were thrown among the snow, and as the temperature was very little above zero they were at once congealed without a struggle.

We returned at evening to my residence in Durham, with my sleigh loaded to its utmost capacity with frozen eels. The quantity was not less than eight or ten bushels.

During the night they were placed in a cold and exposed room and were literally as stiff and almost as brittle as icicles. The next morning a tub was filled with them into which was poured a quantity of water drawn from the well and they were then placed in a warm stove-room for the purpose of thawing. In the course of an hour or two the family were astonished to find them resuscitated and as active as if just taken during the summer.

The experiment was tried with a number of tubs full during the day and with similar results.

How long they would have retained their vitality sufficient to allow of resuscitation I know not—but the presumption is that it would not diminish so long as they were preserved at a temperature much below the freezing point.

The eel is known to be more tenacious of life than many more delicate species of fish, yet it is believed that even tenderer kinds can be resuscitated after having been suddenly frozen at the moment they are captured.

We should be gratified to learn from some of the people about Markham's pond whether a similar occurrence has been known in recent years, of the descent of the eels from the reservoir. It had once happened a few years previous to that above noticed.

Cleveland, Ohio, July 15, 1850. J. P. KIRTLAND.

IV. Astronomy.

New Planet Irene, (Gould's Astr. Jour.)—On the 19th May, 1851, Mr. J. R. Hind of London, discovered a new planet resembling a star of the 9th magnitude. Its place May 19, $12^h\ 52^m\ 36^s$ m. t. Gr., was in R. A. $16^h\ 4^m\ 10^s{\cdot}41$ and South decl. $13°\ 23'\ 34''{\cdot}9$.

The following elements of its orbit are by Mr. James Ferguson of U. S. National Observatory.

Mean Longitude, June 10.0, 1851, m. t. Gr.	41° 57′ 9″·5
Longitude of node, - - -	87 47 46″·2
" perihelion, - -	191 8 27 ·5
Inclination, - - - -	8 37 35 ·7
Angle of excentricity, - -	8 40 50 ·5
Semi-axis major, - - -	0·4069322
Mean daily motion, - - -	870″·18

This is the fourth planet discovered by Mr. Hind, and the fourteenth of the group between Mars and Jupiter.

"Sir John Herschel, who was requested by Mr. Hind to give a name to the planet, has proposed the name *Irene* (Εἰρήνη) in allusion to the peaceful sentiments which should be fostered by the great industrial exhibition now holding in London, where the planet was discovered."

The planet Irene was also discovered independently, by M. Gasparis, on the 24th of May, 1851.

V. Miscellaneous Intelligence.

1. *Smithsonian Institution.*—The following observations on the registry of Periodical Phenomena, have been issued in a circular by the Smithsonian Institution: and may prove useful to many of our readers, as well as to the cause of science.

Registry of Periodical Phenomena.—The Smithsonian Institution, being desirous of obtaining information with regard to the periodical phenomena of Animal and Vegetable life in North America, respectfully invites all persons who may have it in their power, to record their observations, and to transmit them to the Institution. The points to which particular attention should be directed, are the first appearance of leaves and of flowers in plants; the dates of appearance and disappearance of migratory or hybernating animals, as Mammalia, Birds, Reptiles, Fishes, Insects, &c.; the times of nesting of Birds, of moulting and littering of Mammalia, of utterance of characteristic cries among reptiles and insects, and any thing else which may be deemed noteworthy.

A list of plants is appended, to which particular reference should be had in making observations. It has been prepared from materials furnished by Dr. John Torrey and others, and will be found to contain many species distributed throughout the United States, together with a number indigenous to, or cultivated in Europe. For the present, attention may be paid alone to the time of flowering of these species, this period in all cases being indicated by the first appearance of the anther in the expanding flower.

The Smithsonian Institution is also desirous of obtaining detailed lists of *all* the animals and plants of any locality throughout this continent. These, when practicable, should consist of the scientific names, as well as those in common use; but when the former are unknown, the latter may alone be employed. It is in contemplation to use the information thus gathered, in the construction of a series of tables, showing the geographical distribution of the animal and vegetable kingdoms in North America.

List of Plants to be particularly observed.

Acer rubrum, L., Red or soft maple.
—— pseudo-platanus, L., European sycamore.
—— saccharinum, L., Sugar maple.
Achillea millefolium, L., Millefoil or yarrow.
Actea rubra, Willd., Red baneberry.
—— alba, Bigelow, White baneberry—necklace weed;
Asclepias (syriaca) cornuti, L., Milkweed.
Æsculus hippocastanum, L., Horsechesnut, (fruit rough and prickly.)
—— glabra, Willd., Ohio Buckeye, (fruit rough and prickly.)
—— pavia, or flava, Ait., Yellow buckeye; (fruit smooth.)
Ailanthus glandulosus, Tree of heaven.
Amelanchier canadensis, Torr. and Gray, Shad bush, serviceberry.
Ampelopsis quinquefolia, Michx., American ivy—Virginia creeper.
Alisma plantago, L., Water plantain.
Amygdalus nana, L., Flowering almond.
Anagallis arvensis, L., Pimpernel, Poor man's weather glass.
Anemone nemorosa, L., Wind flower; wood anemone.
Aplectrum hyemale, Nutt., Putty root, or Adam and Eve.
Apocynum androsæmifolium, L., Dogbane.
Aquilegia canadensis, L., Wild columbine.
Amaryllis atamasco, L., Atamasco lily.
Arethusa bulbosa, L., Arethusa.
Arum triphyllum, L., Indian turnip.
Aristolochia sipho, D'Her., Dutchman's pipe.
Azalea nudiflora, L., Common red honeysuckle.
Bignonia (Tecoma) radicans, Juss., Trumpet creeper.
Catalpa bignonioides, Walt., Catalpa tree.
—— Indian bean.
Caltha palustris, L., Marsh marigold.
Carpinus americana, Michx., Hornbeam, ironwood.
Celastrus scandens, L., Bitter sweet, wax work.
Convolvulus purpureus, L., Common morning glory.
Cercis canadensis, L., Red bud; Judas tree.
Chelidonium majus, L., Celandine.
Chionanthus virginica, L., Fringe tree.
Cimifuga racemosa, Ell., Black snake root; rattle snake root.
Claytonia virginica, L., Spring beauty.
Corchorus japonicus, Yellow rose; (flowers all the year.)
Cornus florida, L., Flowering dogwood. (The time of expansion of the real flower, not of the white involucre.)
Cratægus crus-galli, L., Cockspur thorn.
—— coccinea, L., Scarlet fruited thorn.
—— oxycantha, L., English hawthorn.
Cynoglossum officinale, L., common hound's tongue.
Dentaria laciniata, Muhl., Cut leaved toothwort.
Dicentra cucullaria, D. C., Dutchman's breeches.
Digitalis purpurea, L., Purple fox-glove.
Draba (Erophyla) verna, L., Whitlow grass.
Epigæa repens, L., Trailing arbutus; ground laurel.
Erythronium americana, Smith, Dog tooth violet, or adder's tongue.
Geranium maculatum, L., Cranesbill.
Gentiana saponaria, L., Soapwort gentian.
Gleditschia triacanthos, L., Three thorned acacia, honey locust.
Gillenia trifoliata, Moench., Indian physic.
Gymnocladus canadensis, Lam., Kentucky coffee-bean tree.
Halesia tetraptera, Willd., Snow-drop tree.
Hepatica triloba, Chaix., Round lobed liverwort.
Houstonia cærulea, Hook, Bluets, innocence, &c.
Hypericum perforatum, L., St. John's wort.
Hydrangea arborescens, L., Wild hydrangea.
Iris versicolor, L., Large blue flag.
Juglans regia, L., English walnut.
—— nigra, L., Black walnut.
Kalmia latifolia, L., Mountain laurel.
Lamium amplexicaule, L., Dead nettle.
Laurus benzoin, L., Benzoin odoriferum, Nees., Spice bush, Benjamin bush.
Lappa major, (Arctium lappa,) Gærtn., Common burdock.
Ligustrum vulgare, L., Common privet.
Lobelia cardinalis, L., Red cardinal flower.
Lonicera periclymenum, L., Foreign spurs.
—— sempervirens, Ait., trumpet honeysuckle.

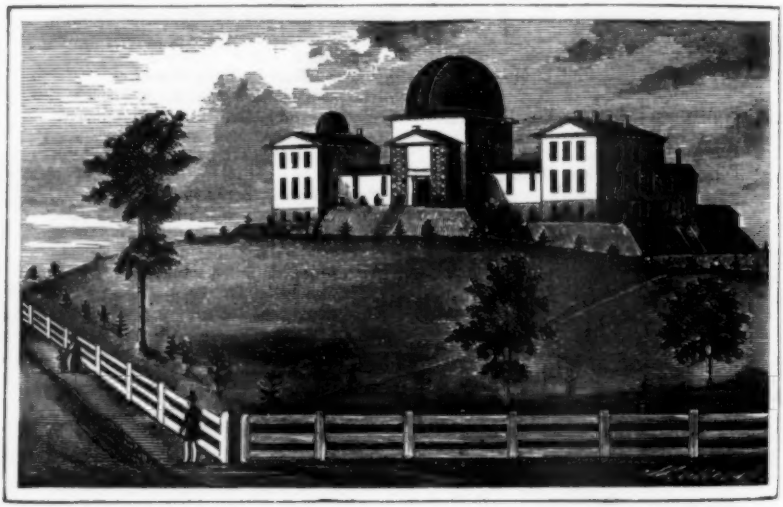
Lonicera tartarica, L., Foreign spurs.
Linaria vulgaris, Mill., Common toad flax.
Lupinus perennis, L., Wild lupine.
Lilum philadelphicum, L., Wild lily.
Liriodendron tulipifera, L., Tulip tree, American poplar.
Magnolia glauca, L., Small or laurel magnolia, sweet bay.
Morus rubra, L., Red mulberry.
Nuphar advena, Ait., Yellow pond lily, splatterdock.
Nymphæa odorata, Ait., Sweet scented water lily.
Orontium aquaticum, L., Golden club, neverwet.
Oxalis violacea, L., Violet wood sorrel.
Platanus occidentalis, L., Buttonwood, sycamore.
Persica vulgaris, L., Peach.
Podophyllum peltatum, L., Mandrake, May apple.
Pentstemon pubescens, Sol., Downy pentstemon.
Pontederia cordata, L., Pickerel weed.
Populus tremuloides, Michx., American aspen.
Pogonia ophioglossoides, Nutt., Adder's tongue.
Ptelea trifoliata, L., Shrubby trefoil.
Pulmonaria (Mertensia) virginica, D. C., Lungwort.
Pyrus communis, L., Common pear tree.
Pyrus malus, L., Common apple tree.
Quercus alba, L., White oak.
Rhamnus cathartica, L., Common Buckthorn.
Rhus cotinus, L., Smoke tree.
—— typhina, L., Staghorn sumac.
Rhus glabra, L., Smooth sumach.
Ribes rubrum, L., Currant.
—— grossularia, L., Gooseberry.
Robinia pseud-acacia, L., Common locust.
—— viscosa, Vent, Clammy locust.
Rosa centifolia, L., Hundred leaved or cabbage rose.
—— Carolina, L., Swamp rose.
Rubus odoratus, L., Purple flowered raspberry.
Sagittaria sagittifolia, L., Arrow weed.
Sambucus canadensis, L., Common elder.
—— nigra, L.
Sanguinaria canadensis, L., Blood root.
Saponaria officinale, L., Soapwort, bouncing bet.
Sarracenia purpurea, L., Side-saddle flower.
Saxifraga virginiensis, Michx., Early saxifrage.
Sassafras officinale, Nees., Sassafras.
Silene pennsylvanica, Michx., Wild pink.
Smilacina bifolia, Ker., 2 leaved Solomon seal.
Staphylea trifolia, L., American bladder nut.
Syringa vulgaris, L., Lilac.
Symplocarpus fœtidus, Salisb., Skunk cabbage.
Tilia americana, L., Bass wood, white wood, American lime, or linden.
Tradescantia virginica, L., Spider-wort.
Ulmus americana, L., American elm.
Verbena hastata, L., Blue vervain.
Viburnum opulus, L., Snowball bush.
—— opulifolium, Mx., Nine bark.
Viola lanceolata, L., Lance leaved violet.
—— cucullea, Ait., Hood leaved violet.
Vitis æstivalis, Mich., Summer grape.

First appearance of the following animals, and if possible, time of depositing eggs.

Pandion carolinus, Gm., Fish hawk.
Hirundo purpurea, L., Martin.
Tardus migratorius, L., Robin.
Sialia Wilsonii, Sw., Blue bird.
Agelaius phœniceus, L., Red wing blackbird, and any other species of birds.
Salmo salar, L., Salmon.
Alosa, Shad.
Acipenser, Sturgeon.
Cry of toads and frogs.
—— Catydid.
—— Locust. (Cicada.)
Appearance of fire-flies.

2. *The Cambridge Observatory*, (Contributed for this Journal, through J. Smith Homans, Esq., Boston.)—This Observatory is situated on a commanding eminence called Summer House Hill, the summit of which is about fifty feet above the plain on which are erected the buildings of the University. This height is found to give from the dome an horizon almost uninterrupted to within two or three degrees of altitude. The grounds appropriated to the use of the Observatory comprise about six and a half acres. It is distant nearly three-fourths of a mile northwest from University Hall, and three miles and a half in the same direction from the State House in Boston.

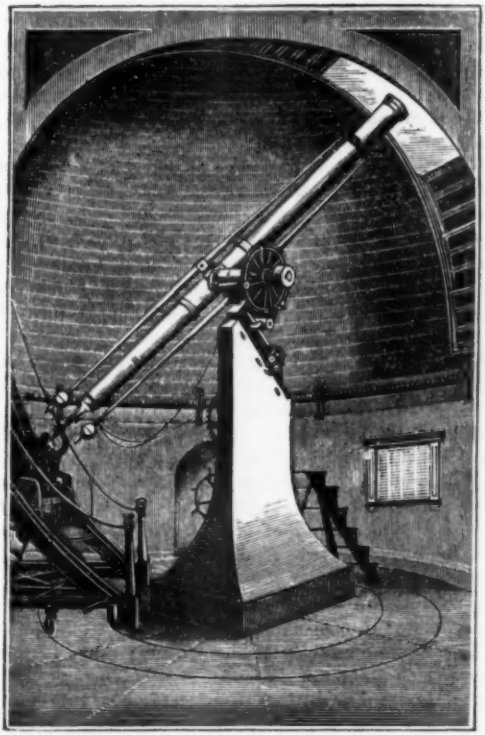
The wonder and admiration caused by the unexpected appearance of the great comet in March, 1843, was a great incentive to, and indirectly, one of the principal causes of the erection of this now celebrated Observatory, although for many years before it had been a favorite project with John Q. Adams, Nathaniel Bowditch, and other distinguished advocates of astronomical science. But few decisive steps were taken, however, until the sudden appearance of this brilliant comet, in 1843, when it was found that the instruments in Cambridge were entirely inadequate to make accurate observations on such a body. This aroused the public-spirited citizens of Boston to a sense of the importance of an Astronomical Observatory, with instruments of sufficient accuracy to make the necessary observations on the heavenly bodies. Accordingly,



an informal meeting was held in the office of the American Insurance Company, Boston, by several public-spirited individuals who were interested in the cause. Soon after, a large meeting of merchants and others was held in the hall of the Marine Society, where it was resolved to raise by subscription the funds necessary for procuring an equatorial telescope of the first class, and twenty-five thousand dollars were immediately subscribed. Mr. David Sears, of Boston, headed the list by a donation of five hundred dollars for this object, besides giving five thousand dollars for the erection of a suitable tower to contain this instrument. Another gentleman of Boston subscribed one thousand dollars towards the telescope; eight others contributed five hundred dollars each, for the same object; eighteen gentlemen gave two hundred each, and thirty others gave the sum of one hundred dollars each. The American Academy of Arts and Sciences made a donation of three thousand dollars, and the Society for the Diffusion of Useful Knowledge gave one thousand. Besides these, the principal Insurance Companies of Boston contributed largely. The American, Merchants', and Na-

tional Insurance offices, and the Humane Society, gave five hundred each; two other companies subscribed three hundred; and two others gave, respectively, two hundred and fifty, and two hundred. Thus in a short time an amount was subscribed sufficient for procuring the instrument which has contributed so much to the advancement of astronomy generally, besides reflecting so much honor on the country at large.

The Sears Tower.—The engraving annexed is a correct representation of the Grand Refractor, which is placed in the Sears Tower, or central building of the Observatory, and in the preceding sketch a correct view is given of the South front of the Observatory and its two wings.



The site of the Observatory was purchased by the corporation of Harvard University. The Sears Tower, so called in honor of David Sears, whose generous donation we have already mentioned, is built of brick, on a foundation of granite laid with cement. It is thirty-two feet square on the outside, while on the inside the corners are gradually brought to a circular form for the better support of the dome, forming a massive arch. This dome, covering the grand equatorial, is a hemisphere of thirty-two feet interior diameter, made with stout ribs of plank, and covered externally with copper. There is an opening five

feet wide, and extending a few degrees beyond the zenith; which is closed by weather-proof shutters, and worked by means of an endless chain and toothed wheels.

On the lower side of this dome is affixed a grooved iron rail, and on the granite cap of the wall is placed a similar rail; between these grooves are placed eight iron spheres, accurately turned, on which the dome is revolved. The apparatus for moving the dome consists of toothed wheels, geared to a series of toothed iron plates, fastened to its lower section. By means of this the whole dome, weighing about fourteen tons, can be turned through a whole revolution, by a single person, in thirty-five seconds. In this dome are placed the "Grand Refractor," and one or two smaller instruments. The Comet Seeker, a small instrument of four inches aperture, by Merz, is used from the balconies of the dome. This is the instrument with which the younger Bond has discovered no less than eleven telescopic comets, before intelligence had reached him of their having been seen by any other observer. From these balconies a most extensive and beautiful view of the neighboring towns, meets the eye.

On either side of the tower is a large wing. Of these the eastern is used as a dwelling for the observer; the western, on which is placed the smaller dome, is used for magnetic and meteorological observations. This wing was erected in the years 1850–51, and adds greatly to the architectural beauty of the Observatory. In this dome is placed the smaller equatorial, of five feet focal length, and an object-glass of four and one-eighth inches, made by Merz, which is a remarkably fine instrument.

The "Grand Refractor," justly considered second to none in the world, has already become celebrated in the hands of the skillful and scientific director and his assistant, from the many brilliant discoveries which have been made with it. Among these we may particularly mention the new ring and satellite of the planet Saturn. It has also enabled the observers to resolve the principal nebulæ, particularly those in the constellations Orion and Andromeda. The object-glass was made at the celebrated manufactory of Merz and Mahler, in Munich, Bavaria, who also were the makers of the celebrated telescope at the Pulkova Observatory, which is of the same size and mounting as that in Cambridge. The same artists also made the Washington and Cincinnati equatorials, besides many others of a smaller size in the United States. The extreme diameter of this object-glass is fifteen and a half inches, although the effective diameter is only fourteen and ninety-five hundredths inches: the focal length is twenty-two feet six inches; the total weight nearly three tons; yet the friction is so successfully relieved by the judicious arrangement of wheels and counterpoises, that it could be pointed to any quarter of the heavens by the finger of a child.

A siderial motion is communicated to the telescope by clock-work, by which means an object may be constantly kept in the field of view, which essentially aids the observer in delicate examinations of celestial objects. The right-ascension is read off by means of an hour circle, eighteen inches in diameter, reading to one second of time by a vernier, while the declination circle is twenty-six inches in diameter, reading also to one second of time or four seconds of arc. The total

cost of the instrument was $19,842. The object-glass arrived in Cambridge on the 4th of December, 1846, but the tube and mounting did not arrive until the 11th of June following. The instrument was mounted on the 23d of June, 1847, and on the evening of the same day was first pointed to the heavens.

The tube of the telescope is of wood, veneered with mahogany and polished on the outside. Within, it is lined with paper, and is strengthened with iron diaphragms. The flexure of the tube is counteracted and its balance preserved by two brass rods seventeen feet in length, having at their extremities nearest the eye-end, brass spheres filled with lead, eight inches in diameter. These rods turn on a universal joint near the middle or centre of motion, and oppose the influence of gravitation on the longer and heavier part of the tube in every position. The centre of motion of the whole instrument is twelve feet nine inches above the floor of the dome. The focal length of the finder telescope is forty-five inches, and its aperture three inches.

The transit circle is by Sims of London. The object-glass, by Merz, is four and one-eight inches aperture, and sixty-five inches focal length. The circles are four feet in diameter, being cast in one piece, and are both graduated on silver from 0° to 360° into five minute spaces, which are again subdivided by micrometers, a single division of the micrometer head being equal to one second of arc, and may be read to two-tenths of a second.

Besides these, the Observatory is furnished with many smaller instruments, and a complete set of meteorological instruments, an astronomical clock, and siderial chronometers.

One of the most ingenious contrivances connected with the Observatory is the "observer's chair," invented by the director. By means of this chair, the observer can transport himself to any part of the dome without moving from his seat.

The new method of finding the motion of the earth has been tried at the Observatory, and also by Prof. Horsford, at the Lawrence Scientific School.

During the Summer of 1848, the director being engaged with the United States Coast Survey in determining differences of longitude, turned his attention to the electro-magnetic method of recording astronomical observations. The apparatus which it has been found convenient to adopt at this Observatory, consists of a *Grove's battery*, a *circuit-breaking siderial clock*, and a "*spring-governor*." These are connected by means of copper wires, leading to all the principal instruments.

The *spring-governor* is a machine devised to carry a *cylinder* with an equable rotary motion, so that it may make one entire revolution in one minute of siderial time; on this cylinder the commencement and termination of each second of the astronomical clock is recorded in exact coincidence with the beats of the clock, the observer at each telescope is furnished with a break-circuit key, by means of which he is enabled to cause a record of his observation to be made on the paper covering the cylinder of the spring-governor among the second marks of the clock, in such a manner that the tenths, and even hundredths of a second may be read off without difficulty, as the sheet of paper, when

unrolled, presents the vertical columns in even minutes, and the horizontal in seconds.

The clock signals are also readily connected with the lines of the telegraph offices, by means of properly arranged switches, so that in effect the beats of the Cambridge clock are as distinctly heard at the offices in Boston, Lowell, Burlington, and elsewhere, as they are within a few feet of the clock, the only limit being the power of the battery; by commencing at the even minute, the time is given all along the line, and this is found very convenient in regulating the starting of the Railroad trains. This method has been subjected to a long and satisfactory trial, and is now considered as a permanent regulation in this Observatory.

The instrument is mounted according to the German form, which has been objected to from the fact that it requires reversal whenever the object under examination crosses the meridian. This is felt as a practical inconvenience in the Cambridge equatorial, only in small zenith distances, since in most instances the telescope passes the meridian by more than an hour of right ascension, and always by more than two hours in southern declinations.

There are but one or two points in which the instrument has been found susceptible of improvement. The arrangement of both the declination and hour circles is inconvenient, causing some needless trouble in reading off the angles.

3. *The Solar Eclipse.*—The solar eclipse of July 28, was observed at Cambridge, Mass., as follows:

For the beginning, expressed in mean solar time of the Observatory.

By R. T. Paine, using a refracting telescope of 54 in. focal length and 3 in. aperture, power 40—$7^h\ 49^m\ 35{\cdot}28^s$.

By S. C. Walker, equatorial refracting telescope of $4\frac{1}{2}$ in. aperture and 5 feet focal length, power 50—$7^h\ 49^m\ 35{\cdot}34^s$.

By W. C. Bond, Daguerreotype telescope with achromatic eye-piece, focal length 9 feet, Sun's image thrown on a white field—$7^h\ 49^m\ 38{\cdot}97^s$.

By C. W. Tuttle, comet-seeker equatorially mounted, 4 in. aperture, power about 15—$7^h\ 49^m\ 44{\cdot}08^s$.

By T. H Safford, with screen of blue tinge without a telescope—$7^h\ 50^m\ 35^s$.

At the end of the eclipse the sun was obscured by clouds. To the unwearied and skillful exertions of J. A. Whipple, we are indebted for a series of daguerreotype impressions of the progress of the eclipse, taken in the small dome of the west wing of the Observatory.

W. C. Bond, *Cambridge.*

Observations were made at Burlington, N. J., with a 5 feet equatorial telescope, and from the very favorable state of the weather were quite satisfactory; beginning $7^h\ 31^m\ 54^s$, and ending $9^h\ 5^m\ 32^s$. Latitude of the observatory 40° 4′ 51″·6. Saml. J. Gummere.

4. *Science of Pisa.*—Pisa is a fine city, and its university contains the best general collection in zoology, geology, mineralogy and botany in all Italy. It is justly celebrated at home for the high character of its scientific men, and deserves to be generally applauded for their sakes. Chas. Matteucci,—the two Savi, sons of the renowned G. Savi,

Professor of botany at Pisa until his death,—Joseph Meneghini professor of mineralogy and geology,—Piria, the chemist, are all names of just celebrity, and we found them most agreeable and enthusiastic men. Prof. Meneghini is a young man and has held his office only two years in place of his unfortunate predecessor Prof. Pila, who was shot in one of the republican battles of 1848. He is also a zoologist and botanist, and has edited "Observazione Postume di Zoologia Adriatica del Prof. Stefano Andrea Renier, Venezia, 1847, containing 16 plates in folio, principally occupied with figures of sponges."—*Correspond. of B.S., Jr.*

5. *Fish of Mt. Bolca.*—At Padua we found the most complete collection of the fossil fish of Mt. Bolca, probably in the world; over 500 specimens, generally presenting both sides, some of them five or six feet long, and all remarkably perfect. We visited this celebrated locality last Friday. It is in a very wild and romantic region, surrounded by lofty mountains. Mt. Bolca itself is 2000 feet high; and to the north and east, the Tyrolese Alps rise abruptly, leaving a profound and steep valley between them and the base of Bolca. Columnar basalt in regular forms crowns the summit and intrudes between the vertical fish-beds.—*Correspondence of B. Silliman, Jr., dated Milan, June* 30, 1851.

6. *The Werner Festival at Freyberg*, (Architect; from the Athenæum, June 21, No. 1234.)—The memory of the great founder of geology is becoming dearer to his numerous disciples every year. Thus, the late commemorative festival was very numerously attended. After the procession had been formed in the halls of the Mining Academy, it proceeded by torchlight to the ancient cathedral. Passing the venerable piles of the huge cloister, it arrived at the monument of Werner, richly decorated; and by the portal of Byzantine origin entered the wide halls of the church. Prof. Breithaupt, as senior of the professors, delivered an oration in honor of the man whose pupils are now spread over the whole globe. The procession was then joined by 700 miners, attired in their mediæval costume. When Werner became professor in Freyberg, it was exclusively a Saxon institution; but, under him it embraced, besides 981 natives, 700 foreigners, and amongst them 236 not Germans, and 33 pupils from all parts of the globe—some among them now occupying the highest rank in the mining profession.

7. *Monticelli's collection of Minerals at Naples for sale.*—This collection, now in the hands of a nephew of the late Monticelli, the distinguished Italian mineralogist, is offered for sale. It contains 4000 specimens. There are over 400 Vesuvian specimens, containing the largest and finest suite of Vesuvian species and varieties extant, all thoroughly labelled. Besides these, it includes also a beautiful series of Elba and Sicilian minerals, and a general collection rich in the species of the most celebrated European localities. Farther information may be had by applying to the editors of this Journal.

8. *Correction.*—The following note has been received for publication from B. A. Gould, Jr.—Prof. Airy has most kindly called my attention to an important error in the publication of my Report on the Velocity of the Galvanic Current in Telegraph Wires, and which is due solely to my own inadvertence. On page 92 of the Proceedings of the American Association at their New Haven meeting; page 156 of the last volume of your Journal, and page 20 of the extract in pam-

phlet form, the tables for the St. Louis and the Louisville signals have been mutually interchanged. The correctness of the published results is however not affected, as the error occurred during the preparation of the manuscript for the press.

9. *Letters from Christiania* announce that the Swedish government is fitting out an Expedition for the circumnavigation of the world.

OBITUARY.

Sir JAMES GRAHAM DALYELL, the eminent naturalist, and President of the Society for Promoting the Useful Arts in Scotland, died in Edinburgh, on the 7th June, at the age of seventy-seven.

VI. BIBLIOGRAPHY.

1. *Reports of the Secretary of War, with Reconnaissances of Routes from San Antonio to El Paso;* by Brevet Lt. Col. J. E. JOHNSTON, Lieut. W. F. SMITH, Lieut. F. T. BRYAN, Lieut. N. H. MICHLER, and Capt. S. G. FRENCH of the Quartermaster's Department. Also the Report of Capt. R. B. MARCY's *Route from Fort Smith to Santa Fe;* and the Report of Lieut. J. H. SIMPSON, *of an Expedition into the Navajo Country;* and the Report of Lieut. W. H. C. WHITING's *Reconnaissances of the Western Frontier of Texas.* Senate Ex. Doc. No. 64, 31st Congress, 1st Session; 250 pp. 8vo. Washington, 1850.—Like other reports from officers under the Bureau of Topographical Engineers, of which Col. J. J. Abert is at the head, these Reports contain many observations of interest to science, and especially to the Geological and Ethnographic departments. The volume is illustrated by 75 lithographic plates and maps, the former containing views of scenery, of Trap dykes and other geological phenomena, of both individual natives and groups in their sports, of ancient hyeroglyphical inscriptions, and numerous other subjects of interest. We reserve further notice for a future number.

2. *The Banker's Magazine and Statistical Register*, edited by J. SMITH HOMANS, Esq. Published at Boston in monthly Nos. of 84 pages, at $5 per year.—Under the editorship of Mr. Homans, the Banker's Magazine is a work of general learning and research, and of wide and philosophical views with regard to moneyed relations and institutions at home and abroad. It also contains much detailed information respecting the production of the precious metals in different countries as well as their circulation, besides facts and opinons on various collateral topics.

The August number, among its many excellent articles, contains a sketch of the early history of banking, with a variety of details which render the magazine of the first importance to bankers, and to well informed merchants.

The publisher of this able periodical gives notice that the following important and interesting works will be embodied in the volume for the year beginning July 1851, and ending June 1852:—1. New varieties of gold and silver coins and bullion, with important details relating to the coinage, rules of the Mint, &c.; by Jacob R. Eckfeldt and W. E. Dubois, Assayers of the U. S. Mint. 2. The American Law of Banking, a synopsis of the decisions of the higher courts of every State in

the Union upon the subjects of banking, bills of exchange, promissory notes, damages of bills, usury, notaries public, &c.; the decisions of each State will be arranged by themselves commencing with Maine, to be followed in order by New Hampshire, Vermont, Massachusetts, Connecticut, New York, &c. 3. History of Banking and Currency, by W. J. Lawson, Esq.; a recent English work. 4. Historical sketches of the Early Currency among the American Colonies. 5. Gilbart's practical Treatise on Banking, *concluded*. The second American edition of this work entire (470 pp.) may be had of booksellers throughout the United States.

3. *A Guide to the Scientific Knowledge of Things Familiar;* by Rev. Dr. BREWER. From the London edition. 426 pp. 16mo. New York. 1851. C. S. Francis and Co.—This work consists of questions and answers on familiar applications of science and the various physical phenomena of every day life. The questions are such as naturally arise in the mind of a person of ordinary observation; and the work gives simple yet sufficient explanations. The reader will gather a great amount of information from this little volume, and will find it ready to solve many doubts and queries that are suggested by operations in nature around him.

4. *Elements of Latin Pronunciation, for the use of Students in Language, Law, Medicine, Zoology, Botany, and the Sciences generally, in which Latin words are used;* by S. S. HALDEMAN, A.M., Prof. Nat. Hist. Univ. Penn. 76 pp. 12mo. Philadelphia, 1851.—Prof. Haldeman through extensive intercourse with the Indians of this continent and the natives of many other regions, has studied with great success the science of phonetics, and has thus prepared himself for his researches into the true pronunciation of the Latin language. The work therefore commends itself to scholars not only as a treatise on this particular language, but also for its classification of sounds, and for general views on their force, modes of combination, and relations.

5. *The Fourth Annual Report of the Board of Regents of the Smithsonian Institution;* showing the operations, expenditures and condition of the Institution during the year 1849. Washington, 1850.—Besides the other topics of this important report, it contains a detailed descriptive and historical catalogue of the various libraries of the country, made out by Mr. C. C. Jewett, the very able Librarian of the Institution.

6. *Ausführliches Handbuch der Analytischen Chemie*, von HEINRICH ROSE. In two volumes; the first of 968 pages 8vo on Qualitative Analysis, and the second of 1070 pages, on Quantitative Analysis. Braunschweig, 1851.—The Analytical Chemistry of Rose is so well known and so highly appreciated, that we need only announce here that a new edition has appeared in Germany, greatly enlarged. It is the most learned work extant on the subject and the most convenient for the student.

7. *The Journal of Agriculture*, a monthly of 32 pages, edited by WM. S. KING and J. J. MAPES. Boston. The first number of this new Agricultural Journal appeared on the 2nd of July last.

8. *Iconographic Encyclopedia.*—No. 21 of this valuable work published by Rudolph Garrigue, New York, has been issued. The plates sustain the high character promised by the earlier numbers.

Prof. S. St. John: Elements of Geology. 1851. G. P. Putnam.

E. Hitchcock, D.D.: The Religion of Geology and its connected Sciences. *Boston.* 1851. Phillips, Sampson & Co.

Prof. C. B. Adams: Contributions to Conchology, No. 9, containing new species of land shells from Jamaica, and Catalogue of the land shells of Jamaica, pp. 153–188. From the Annals of the N. Y. Lyceum, vol. v, No. 3.

W. R. Birt: The Hurricane Guide; being an attempt to connect the Rotatory Gale or Revolving storm with atmospheric waves. *London.* J. Murray.

W. B. Carpenter: Principles of Physiology, General and Comparative. From the 3d London edition, in one 8vo volume of nearly 1100 pages with 321 wood-cuts. *Philadelphia.*

R. W. Mylne, F.G.S.: A new map of London and its environs, Topographical and Geological. *London.*

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Dr. Charles Robin: Rapport a la Société de Biologie par la commission chargée d'examiner les communications de M. Souleyet, relatives à la question désignée sous le nom de Phlébentérisme. 132 pp. 8vo. *Paris.* 1851. J. B. Baillière.

Proceedings of the Acad. Nat. Sci. Philadelphia, vol. v.—APRIL. p. 170. Note on the Palæotherium Proutii; *J. Leidy.*—p. 171. On the bones of a Reptile supposed to be from the new red sandstone, in the S. E. corner of Lehigh county, Pa.; *I. Lea.*—pp. 172, 173. New Fossil Tortoises, (*Stylemys nebrascensis*, Leidy, *Testudo lata*, L., and *Emys hemispherica*,) from Nebraska Territory; *J. Leidy.*—p. 173. On the paucity of half caste children in New Holland; Dr. *Morton.*—p. 175. On some Caprimulgidæ in the collections of the Academy; *J. Cassin.*—MAY. p. 201 and 212. On the transferring of a portion of tissue of a scirrhous mamma from a female to a frog; *J. Leidy.*—p. 201. On the plants affording gamboge and camphor; Rev. *F. Mason.*—p. 204. A Gryllotalpa americana destroyed by the growth of a Fungus; *J. Leidy.*—p. 205 and p. 224. Contributions to Helminthology; *J. Leidy.*—p. 213. On the Habits of Birds of Western Texas, and descriptions of undescribed species; *Col. G. A. McCall.*

Proc. Bost. Soc. Nat. Hist. JAN., 1851.—p. 1. Remarks on the "Aztec children;" Dr. *J. M. Warren.*—p. 2. New Fossil Echinoderms from the Lower Tertiary of Georgia; *T. T. Bouvé.*—p. 5. New Holothuria of the coast of the United States; *W. O. Ayres.* (New genus Sclerodactyla proposed.)—p. 7. Two new shells of Massachusetts Bay, Spirialis Gouldii, Thracia Couthouyi, and a new Holothuria, Anaperus unisemita; *Wm. Stimpson.*—p. 9. List of fossils of the Post-pliocene of Chelsea; *Wm. Stimpson.*—p. 10. Observation on the shell and sternum of the Trionyx ferox; *J. Wyman.*—FEBRUARY. p. 11. New species of Synapta; *W. O. Ayres.*—p. 12. Species of shells new to Massachusetts Bay; *Wm. Stimpson*, (includes the new species, Rissoa eburnea, R. multilineata, R. Mighelsii, R. exarata, R. pelagica, Turritella acicula, T. arcolata, Chemnitzia modesta, C. interrupta, C. seminuda.)

Proceedings of the Am. Phil. Society, vol. v, No. 46. January to July, 1851.—p. 177. On a large specimen of Gold from California; Mr. *DuBois* The gold of the specimen weighed 265·5 ounces troy; fineness ·902.—p. 187. Observations on Mollusca; *I. Lea.* On the size of certain Naiades from near Cincinnati; *I. Lea.* On the Electro-chronograph; *J. Locke.*

APPENDIX.

The American Association for the Advancement of Science.—The annual meeting of the Association, for 1851, was held at Albany, N. Y., during the week commencing Monday, August 18th. Prof. Agassiz was President of the meeting. The attendance was unusually large, and upwards of 120 papers were presented. The department of Geology and that of Astronomy and Physics were most largely represented, while Zoology received comparatively little attention. The address of Prof. A. D. Bache, President of the year past, was delivered Wednesday evening: it was an able and instructive discourse on the circumstances attending the organization of the Association, its progress, and the direction in which to look for its greatest usefulness.

One of the most important points brought out in the astronomical department, was a new Lunar formula by Mr. Longstreth, containing a correction, according to which an error hitherto disregarded, is eliminated, and a perfect coincidence with observation is obtained. Prof. Mitchel's improved method of observing right ascension and N. P. distance was reported upon by a committee in terms of the highest commendation. In geology, the Taconic system was brought up by Prof. Emmons, and the claims urged for it were ably set aside in remarks by Prof. W. B. Rogers in a paper on the geological features of Western Vermont and Massachusetts, and also by facts brought forward by Prof. J. Hall, Mr. J. W. Foster, and others. In zoology, Prof. Agassiz presented a paper on a new mode of alternate generation, showing that the bulbs of the Tubulariæ are proper Medusæ, remaining attached to the animal and giving out true ova. We must reserve farther remark to our next number.

The Association was treated with the highest liberality by the citizens of Albany, and at the close of the meeting, it was announced that the city would defray the expenses of publishing the volume of Proceedings. By invitation from the city of Troy, there was an excursion to that city on Thursday, where a session was held at the Rensselaer Institute, after which the members were shown to a handsome collation.

Prof. Peirce, of Harvard, was chosen President for the next year. The meeting will be held at Cleveland, Ohio, on the 3d Wednesday in August, 1852, this city having invited the Association and generously offered to publish the Proceedings at the city expense. A similar invitation and offer were received from Brooklyn; but that from Cleveland was of prior date. A semi-annual session was not appointed.

We give below the titles of the papers presented. We would solicit information from members as to any omissions, which we will correct in our next number.

1. Astronomy, Physics, Mathematics.

On the Origin of the Forms, and the present condition of the Cluster of Stars and Resolvable Nebulæ; by Prof. S. Alexander, of Princeton.

On the Atmospheric Envelopes of Venus and other Planets; by the same.

Account of a Meteor seen on the night of Oct. 3, 1850; by Prof. Brocklesby.

On the Solar Eclipse of July 28; by Lieut. Davis, U. S. N.

Additional observations on the tides at Cat Island; by Prof. A. D. Bache, Superintendent of the U. S. Coast Survey.

Notes on the Tides at Sand Key, near Key West; by the same.

On some phenomena bearing on Electrical Theory; by Prof. Joseph Henry.

On Electrical Theory; by Dr. Robert Hare, of Philadelphia.

On a Meteorological Report of Prof. Espy; by the same.

On a problem in the Doctrine of Chances; by Prof. B. Peirce, of Harvard.

An account of Longstreth's Lunar formula; by the same.

On the relation between the square roots of Negative quantities in Algebra and the principles of Perpendicularity in Geometry; by John Paterson, of Albany.

On Daltonism or Blindness to particular Colors; by Prof. McCulloh, of Princeton.

Case of the Tertiary Rainbow; by Charles Hartwell.

On Special Analogies in the Phenomena presented by the two Senses of Sight and Touch; by Prof. S. Alexander, of Princeton.

On the relation between Erect Vision and the Inverted Image of the Retina; by Prof. W. W. Clark, of Albany.

On the Solar Light; by D. VAUGHAN, of Cincinnati.

Daguerreotypes of the late Solar Eclipse, and of Spots on the Sun; by DAVID A. WELLS, of Cambridge.

The bearing of some recent Microscopical results upon the present Theories of Light; by Dr. W. J. BURNETT, of Boston.

On the Zodiacal Light; by Prof. D. OLMSTED, of Yale College.

On deep Sea Soundings; by Lieut. M. F. MAURY, U. S. N.

Observations on the Eclipse of the Sun, July 28th, 1851; by Prof. PHILIP TEN EYCK, of Albany.

Experimental Researches, tending towards an Improvement in the Telescope, by Prof. ALEXANDER C. TWINING, of New Haven.

Results of a set of Observations in repetition of Foucault's Experiments; made at Providence, R. I., by Profs. CARSWELL and NORTON.

On the Pendulum Experiment; by Prof. J. D. DANA, of Yale College.

The Pendulum at Bunker Hill Monument; by Prof. E. N. HORSFORD, of Harvard.

The Effect of Heat on the Perpendicularity of Bunker Hill Monument; by the same.

On the use of air as a medium for conveying mechanical Power; by Lieut. E. B. HUNT.

On the Proper Measure of Mechanical Force; by Prof. J. H. C. COFFIN, of Lafayette College.

The occurrence of placid water in the midst of large areas where waves are constantly breaking; by Prof. HORSFORD.

2. METEOROLOGY.

On the distribution of rain for the month of September; by Prof. E. LOOMIS.

On the Clouds and Equatorial Cloud-rings of the Earth; by Lieut. MAURY, U. S. N., Superintendent of the Washington Observatory.

On Ocean Temperatures; by the same.

A Comparison of the Diurnal Law of the Mean Irregular Fluctuation of the Magnetical Elements at the stations of Observation in North America; by Capt. LEFROY, of the Toronto Observatory.

On the Influence of Terrestrial Electricity on Climates; by D. VAUGHAN.

On the Quantity of Rain at different heights, from observations made at the Institution for the Deaf and Dumb; by Professor MORRIS, of New York.

Temperature at Hartford, Connecticut, with a Map; by Professor BROCKLESBY.

On the Meteorological Observations of New York, from 1825 to 1850; by Dr. FRANKLIN B. HOUGH, of New York.

On the Progress of the System of Meteorological Observations conducted by the Smithsonian Institute, and the propriety of an immediate extension of it throughout the American Continent; by Prof. E. GUYOT, of Cambridge.

3. CHEMISTRY.

Relation of the Chemical Constitution of Bodies to Sight; by Prof. E. N. HORSFORD, of Harvard.

Solidification of the rocks of Florida Reef; by the same.

On the permeability of Metals to Mercury; by the same.

Plasticity of Phosphorus; by the same.

Note on Ammonia in the Atmosphere; by the same.

On the existence of organic matter in Stalactites and Stalagmites, containing Crystallized and Amorphous Crenate of Lime; by D. A. WELLS, Cambridge.

On a New Method for the Analysis of Soils; by the same.

On the Soils of Pike county, Scioto valley, Ohio; by the same.

On the Value of Soil Analysis, and the points to which special attention should be directed; by Prof. JOHN P. NORTON, Yale College.

Comparative Analyses of Ash, from premium samples of 8-rowed yellow Indian corn; by MASON C. WELD, of the Yale Analytical Laboratory, New Haven.

Analysis of Bituminous Coal-ash; by GEORGE W. WEYMAN, Yale Analyt. Lab.

Analysis of the Ash of a Cotton Stalk; by O. JUDD, Yale Analyt. Lab.

On the Volatilization of Phosphoric Acid in acid solutions; by the same.

Analysis of the Cucumber and other substances; by Dr. J. H. SALISBURY, of Albany.

On the Separation of Butter from Cream by catalysis; by President EDWARD HITCHCOCK, of Amherst.

On Phosphoric Acid in normal Human Urine; by Dr. BRIED, of N. Y.

Analysis of the Brain of the Ox; by the same.

On a new mode of making the white oxyd of Zinc; by A. C. FARRINGTON.

On the Isomorphism of the Chemical Compounds comprised under the mineral species, Tourmaline; by Prof. JAMES D. DANA, of Yale College.

On the Analysis of Urinary Calculi; by Prof. J. LAWRENCE SMITH.

On the Homological Relations of the Alcohols and their Derivatives; by T. S. HUNT, of the Geological Commission of Canada.

4. MINERALOGY AND METEORITES.

On the Meteoric Stone of Deal, New Jersey, which fell August 15, 1829; by Prof. C. U. SHEPARD.

On the Probable Data of the Fall of the Ruffs Mountain (S. C.) Meteoric Iron; by the same.

On Chalcodite, a new mineral species; by the same.

On the Alluaudite of Norwich, Mass.; by the same.

Notice of several American Minerals; by the same.

On the Optic and Physical Properties of the supposed "Chlorite" of Westchester, Pa., with the Results of a Blowpipe Examination; by WILLIAM P. BLAKE, Yale Analytical Laboratory.

On the occurrence of Chromate of Lead in Pennsylvania, with other Mineralogical notices, and on a new locality of Red Sapphire; by the same.

On Phosphate of Lime; by Prof. E. EMMONS, of Albany.

On the Distribution of Manganese; by D. A. WELLS, Cambridge Laboratory.

On the Octahedral Peroxyd of Iron; by T. S. HUNT, of the Geological Commission of Canada.

On the Columbite of Haddam; by the same.

On the Emery and Associated Minerals of Asia Minor; by Prof. J. LAWRENCE SMITH, of the University of Louisiana, New Orleans.

Notice of a Magnesian Opal; by the same.

An account of the Meerschaum Formation in Asia Minor; by the same.

Upon the metamorphic Condition of Franklinite (N. J.); by A. C. FARRINGTON, of Newark, N. J.

On Houghite; by S. W. JOHNSON, of the Yale Analytical Laboratory.

5. GEOLOGY AND PALÆONTOLOGY.

On some of the Thermal Waters of Asia Minor, with an account of the nature of their locality and composition; by Prof. J. LAWRENCE SMITH, of the University of Louisiana, New Orleans.

On the Metamorphic Coal Field of Massachusetts; by Pres. E. HITCHCOCK.

Remarks and Conclusions respecting Terraces; by the same.

On the Probable age of the Argillaceous slates of the Connecticut Valley; by the same.

On the Geological Age of the Coal-bearing rocks of North Carolina; by Prof. W. B. ROGERS, of the University of Virginia.

Notes on the Geological Structure of Western Vermont and Massachusetts; by the same.

On the passage of anticlinal axes into Faults; by the same.

On the methods adopted in the Geological Survey of Pennsylvania, of investigating and representing the Geology; by Prof. H. D. ROGERS.

On the Lithological and Palæontological characters of the Potsdam Sandstone; by T. S. HUNT, of the Geological Commission, Canada.

Comparison of the Geological Features of Tennessee with those of the State of New York; by Prof. J. HALL, N. Y. State Geologist, Albany.

On the Sill and Drainage of the Mississippi River; by Lieut. M. F. MAURY, U. S. N.

On the Geological Agency of the Winds; by the same.

On the Boulder Hypothesis; by Judge A. OSBORN, of Albany.

On the Origin of Stratification; by D. A. WELLS.

Reply to the objections to the Taconic System; by Prof. E. EMMONS.

Distorted Quartz Vein in Syenite; by A. C. FARRINGTON, of Newark, N. J.

Fault in a Metallic Vein in White Limestone, N. Y.; by the same.

On the Existence of Diluvial Agencies during the Earlier Geological Periods; by Dr. F. B. HOUGH, of New York.

Remarks upon the Unconformity of the Paleozoic Formations of the U. S.; by Prof. L. AGASSIZ.

Remarks upon the Fossils of the Potsdam Sandstone; by Prof. JAMES HALL, N. Y. Geologist, Albany.

Remarks upon the Fossil Corals of the genus Favosites, and allied genera Favistella, Astriocerium, and others; by the same.

Remarks upon the Trilobite of the Potsdam Sandstone, named by Dr. Owen, Dikellacephalus, and its relations to Asaphus and Ogygia; by the same.

On the Palæozoic genera, Trematopora, Cellopora, and allied genera of more recent geological periods; by the same.

Tracks, Trails, &c., in the Shales and Sandstone of the Clinton Group from Green Bay, with remarks on the thinning out and re-appearing of this portion of the Clinton Group; by the same.

On some Reptilian Footmarks of the Infra-carboniferous Red Shale of Pennsylvania; by Prof. H. D. ROGERS.

On the Vegetation of the Infra-carboniferous Rocks of Pennsylvania, and a description of a new genus of Fossil Plants; by the same.

On some New Fossil Plants of the Oolitic Coal of Eastern Virginia; by Prof. W. B. ROGERS.

On the Alternations of Marine and Terrestrial Organic Remains in the Carboniferous System of Ohio; by J. W. FOSTER.

On some Fossils of Northern Ohio; by Prof. J. BRAINERD.

6. ZOOLOGY AND BOTANY.

On a New Type of Alternate Generation observed among Medusæ; by Prof. L. AGASSIZ.

Monograph of the Genera Dysnomia *Ag.*, Complanaria *Sw.*, Lampsilis *Raf.*, and general Remarks on the other Genera of Naiades; by the same.

Points in the Economy of the *Cicada Septendecim*, bearing upon the Plural Origin and Special Local Creation of the Species; by Dr. W. J. BURNETT, of Boston.

Relations of Embryology and Spermatology to Animal Classification; by the same.

On the Geographical Distribution of Animals in California; by Dr. J. L. LE CONTE of New York.

On the Classification of the Mammalia; by C. GIRARD, of Washington.

On the Habits of the Whale; by Lieut. M. F. MAURY, U. S. N.

On two New Species of Juglans; by Prof. J. TORREY.

On the Chenopodiaceæ of North America; by the same.

Views on the Nature of Organic Structure: by Lieut. E. B. HUNT, U. S. Engineers.

7. MISCELLANEOUS.

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On the Distinctive Character of the Indians of California; by Dr. J. L. LE CONTE, of New York.

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On the Proper Geometrical Form of the Mould Board of the Plough; by Rev. CHAS. HACKLEY, of New York.

Observations on the Freezing of Vegetables, and on the Causes which enable some Plants to endure the action of extreme Cold; by Prof. JOHN LE CONTE, of the University of Georgia.

Peculiarities of the Climate, Flora, and Fauna, of the South Shore of Lake Erie, in the vicinity of Cleveland, Ohio; by Dr. J. P. KIRTLAND, of Cleveland.

On the Preservation of Animal Substances; by Dr. H. GOADBY.

Plate II

ZODIACAL LIGHT

AT THE VERNAL EQUINOX LAT 40°16'